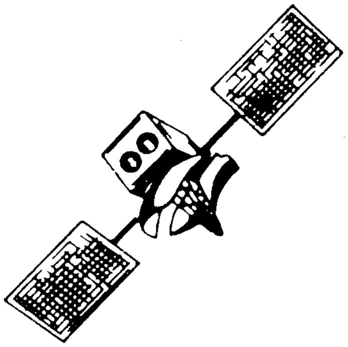

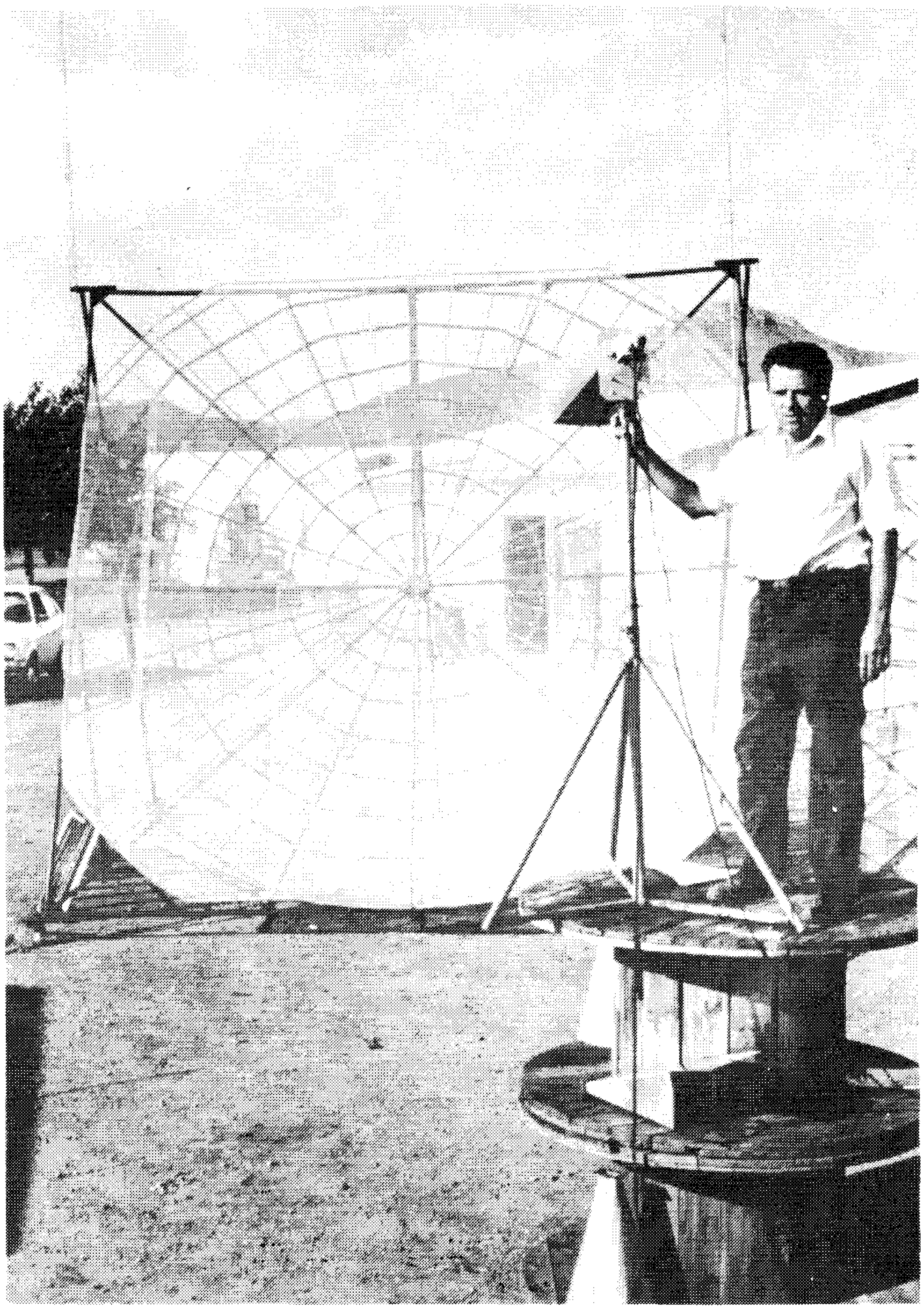

THE SWAN SPHERICAL TVRO ANTENNA

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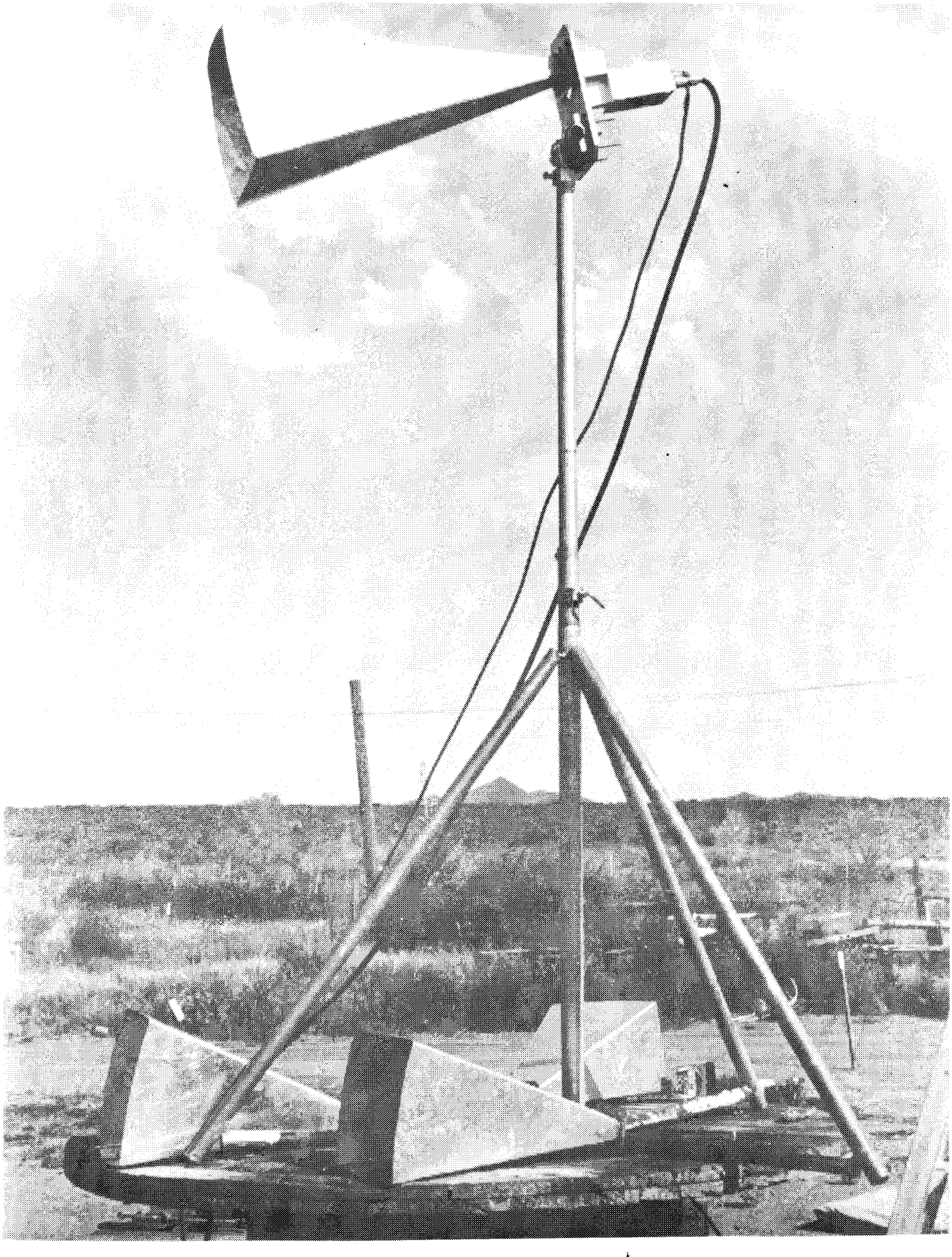

swan spherical

THE SWAN SPHERICAL TVRO ANTENNA MANUAL

...A manual to guide you in the design and construction of a novel, low cost, satellite television antenna system

Produced and distributed by Satellite Television Technology, P.O. Box 2476, Napa, California 94558. Price is $30 per copy and that includes a 'license' for the buyer to duplicate for his own **private**, non-commercial use the innovative design of the Swan Spherical TVRO antenna and the associated experimental feed horn antenna.Commercial manufacture of this antenna is reserved to Swan Antenna Company and those firms designated by royalty agreement by Oliver Swan to duplicate his work.

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THE COVER - Oliver Swan, antenna experimenter, designer and builder extra-ordinaire with his 14 foot Spherical TVRO antenna and empirically derived feed horn near Bisbee, Arizona.

On Christmas Eve [1979] Oliver Swan passed away. Oliver was stricken with cancer in October and was confined to bed and finally hospitalized until his death. The Swan Spherical TVRO Antenna described herein is the result of more than twenty years of experimentation by Oliver Swan. Nobody will ever replace Oliver's creative genius. Oliver would have wished however that enthusiasts carry on with his work and to his memory and the improvements others will develop, this manual is dedicated. Oliver's brother, Henry Swan, is continuing to produce this antenna on a commercial basis and may be reached through the Oliver Swan address shown in the rear of this manual.

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INTRODUCTION

This manual will show you how to design and construct your own "low cost" satellite signal receiving antenna system. The antenna "family" to be described is related to the popular parabolic antenna commonly employed for satellite (television) receiving systems; but not as closely as you might first suspect.

This manual will not dwell on the theory of the Spherical Antenna reflector nor on the theory behind the operation of the "horn" feed antenna system. Frankly, while the Spherical reflector may be an effective antenna for the satellite reception service application, it is not without some controversy in professional circles. Therefore this manual will concentrate on the mechanical construction and operation of the Spherical reflector and its mating "horn feed" as developed and put into operation by Arizona antenna wizard Oliver Swan. Readers intent upon developing their own 'theory' concerning this antenna system are referenced to such manuals as Antenna Engineering Handbook (Henry Jasik, Editor; McGraw-Hill Book Company).

WHAT THE SPHERICAL DOES

The Spherical Reflector presents itself as a 'solid' surface to an incoming wavefront coming from a satellite. Solid, in this instance, means that virtually all of the energy intercepted by the reflector surface reflects from the surface rather than passing through to the rear. The Spherical surface is concave, by design, so that any energy intercepted by the surface from the desired 'point source' (i.e. the satellites in this instance) is 'focused' to a central point. The gain of the Spherical is directly related to:

1) The surface area of the reflective surface (more surface area intercepts more 'point source' signal and therefore more signal is 'focused' to the 'focal point');

2) The efficency of the 'feed' or 'pick-up' antenna that is located (again, by design) at the focal point of the reflector surface.

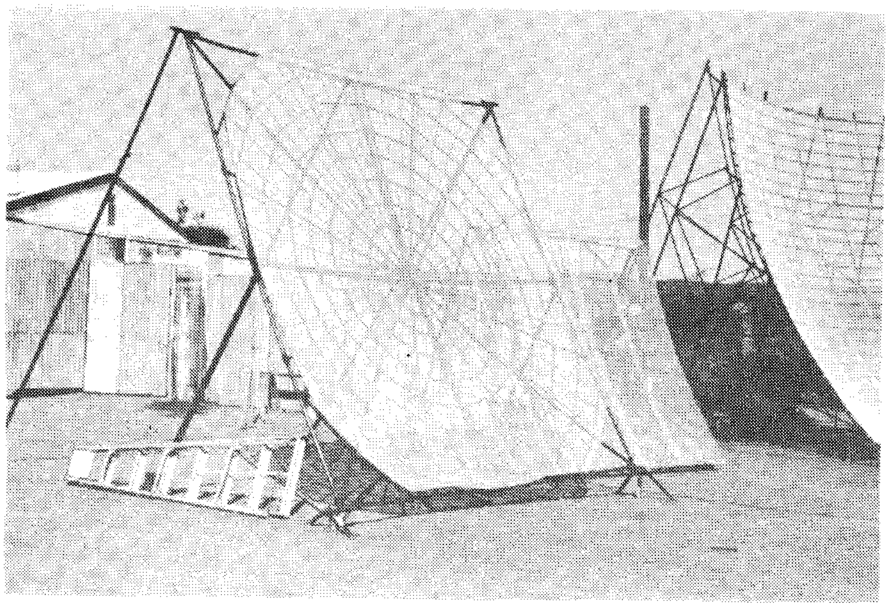
In the frequency band of interest (3.7 to 4.2 GHz) a reflector surface material that has 'holes' (or air gaps) up to approximately 3/16" across acts for all practical purposes like a 'solid' (metal) surface to the incoming point source signals. The maximum permissible 'hole size' is a function of the length of the wavelength at the frequency of interest; higher (and higher) frequency wavelengths require smaller and smaller holes if the reflector surface is to maintain a high degree of 'reflective efficency'. Most 'commercial' (i.e. CATV grade) reflector surfaces utilize solid (metal) surfaces in this frequency range but it turns out that this selection has been made by the designer primarily for reasons of antenna stability and rigidity rather than for reasons of performance. Some of the more recently announced 'fiberglass construction' commercial antennas create their reflective surfaces by sandwiching a metallic mesh (or 'screen') between outer surfaces of fiberglass materials; the fiberglass is the mechanical support system to maintain a 'rigid' reflector surface for the antenna.

SPHERICAL v.s. PARABOLIC

As noted the Spherical Reflector is a member of the same antenna design family as the Parabolic Reflector. A parabola is formed (geometrically) as a curve created by the edges of a plane cutting through a right circular cone at an angle parallel to one of the sides. A Spherical (reflector) in its most basic form is simply a section or portion of a parabola.

swan spherical

Seemingly the parabola and the Spherical would exhibit very similar operating characteristics in as much as the latter is simplistically a part of the former. Alas, there are more dis-similarities than similarities between the two antenna forms.



SWAN 14 FOOT (near), 10 foot (partially shielded) and 20 foot Spherical TVRO antennas at development site near Bisbee, Arizona.

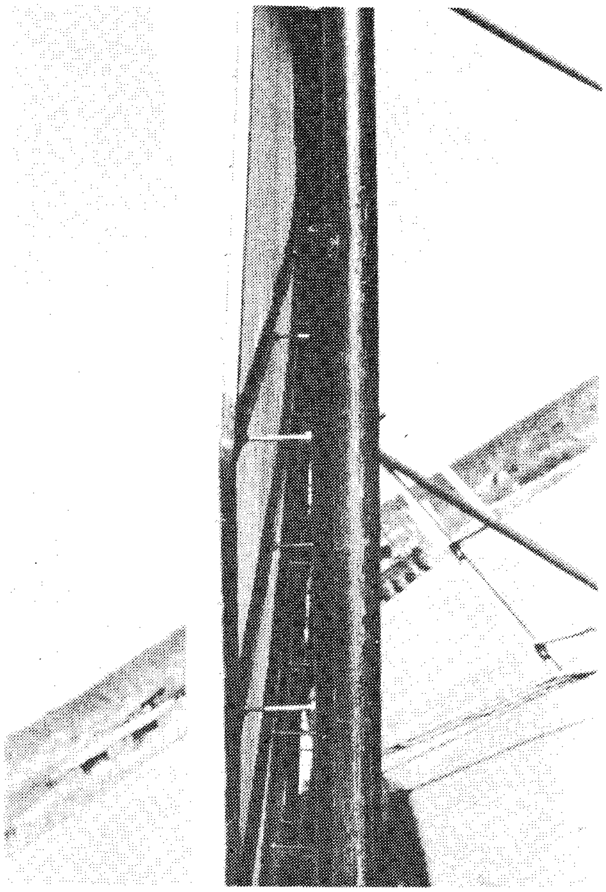
A few of the most important follow:

1) Picture the parabolic antenna as a 'cup'; it must be bore-sighted or pointed directly at the point source (i.e. the satellite) in order for the RF energy intercepted by the reflective surface to be focused at the 'feed antenna' located at the focal point.

2) This direct 'bore-sighting' requirement for the parabolic antenna extends in both planes; i.e. the elevation angle of the parabolic plus the azimuth heading must correspond to a 'dead-on' bore-sight between the exact center of the parabolic surface and the point source in the sky.

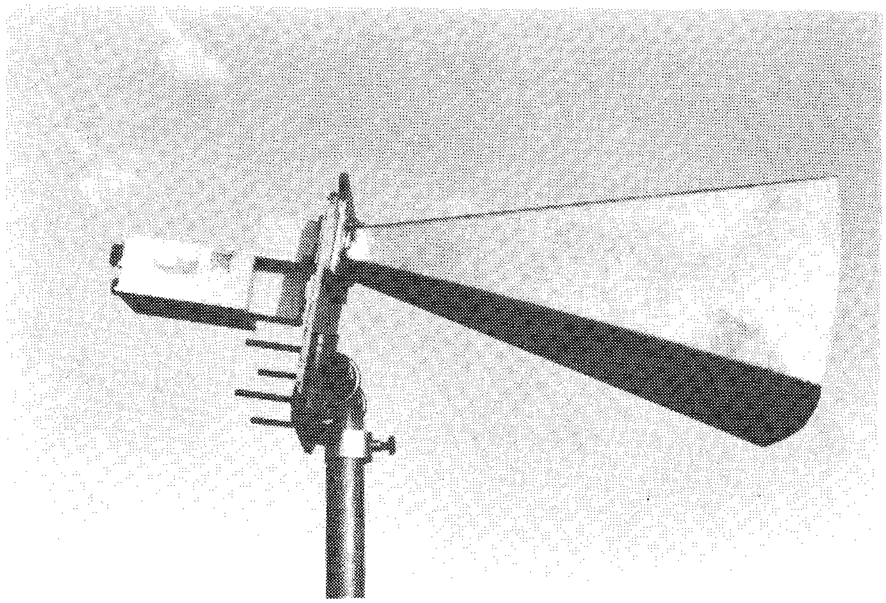
3) The Spherical antenna reflector, on the other hand, has a much more gradual 'parabola shape'; another way of saying that its is much closer to being flat (i.e. a "shallow concave format") than a full parabolic. This in no way detracts from the precise focusing of the point source energy at the focal point but it does make it possible for point sources not directly on the bore-sight of the antenna to still focus left or right of the bore-sight focal point with efficencies (i.e. gain) that remains useable over a much wider portion of the satellite orbit belt.

4) The Spherical reflector provides the User with a means of realizing high efficency (i.e. useful amounts of gain) reception over an orbit-belt-arc of up to 40 degrees, by either moving the feed point antenna

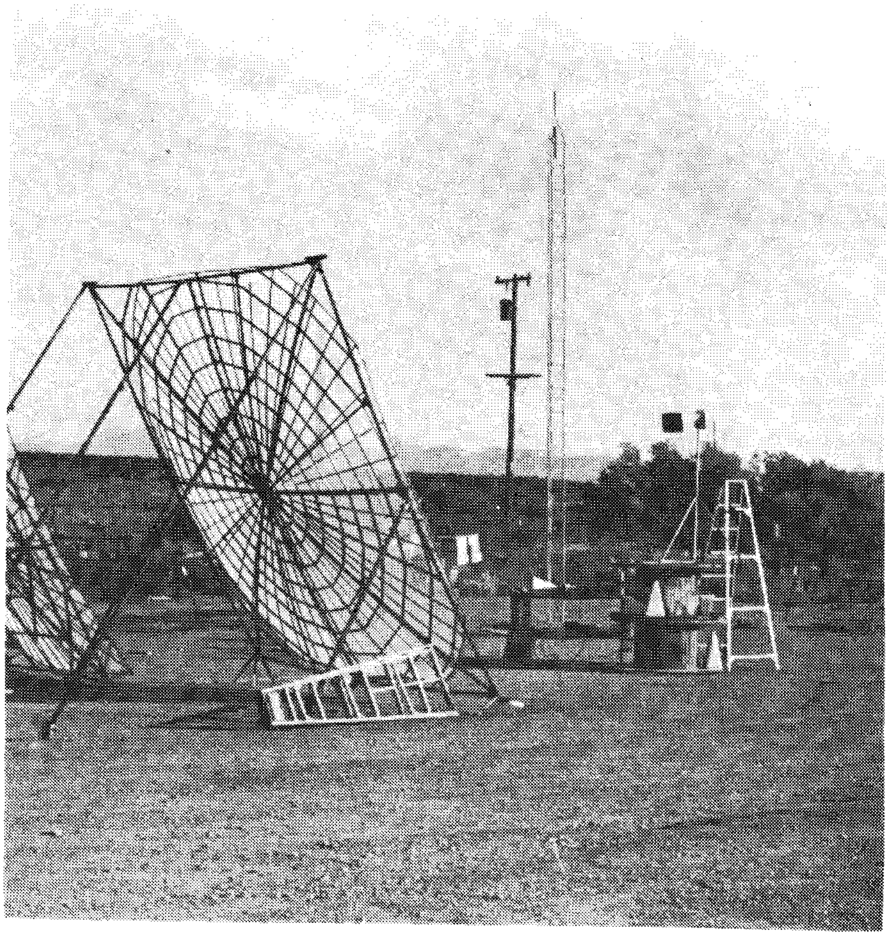


SHALLOW concave shape of Spherical is evident in this side-on view of 14 foot Spherical.

swan spherical



23 INCH FEED HORN mounted in position, flanged to input cavity on (SCI) low noise amplifier on tripod mount/stand.



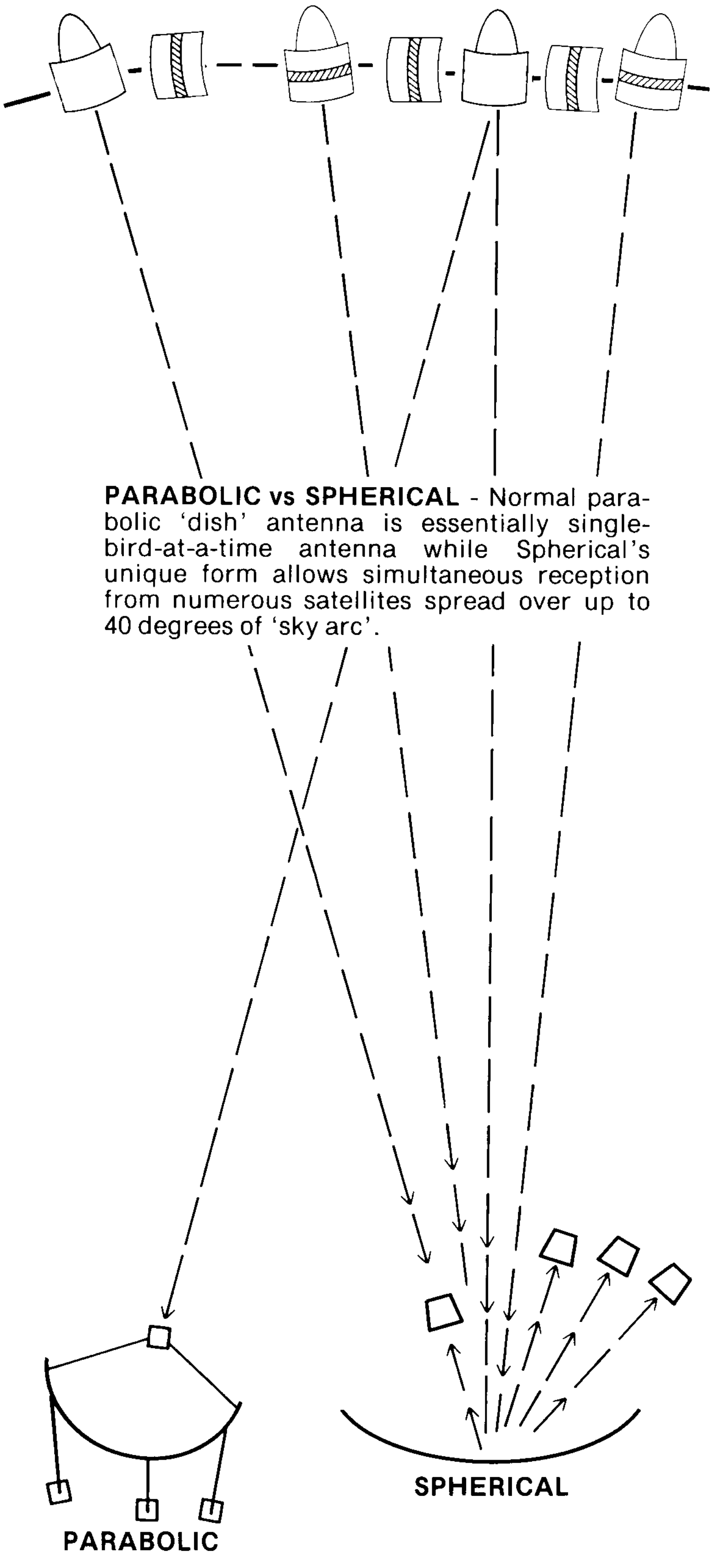
FOURTEEN FOOT SPHERICAL and feed horn in position for reception from satcom fl; note feed horn is elevated on test stand and has slight downward tilt.

along a line parallel to the antenna surface ('left' and 'right' as it were) to predetermined focal spots where the different satellite signals will focus in front of the antenna, or alternately, to locate two or more separate feed point antennas in front of the antenna simultaneously to provide different reception from separate satellites simultaneously.

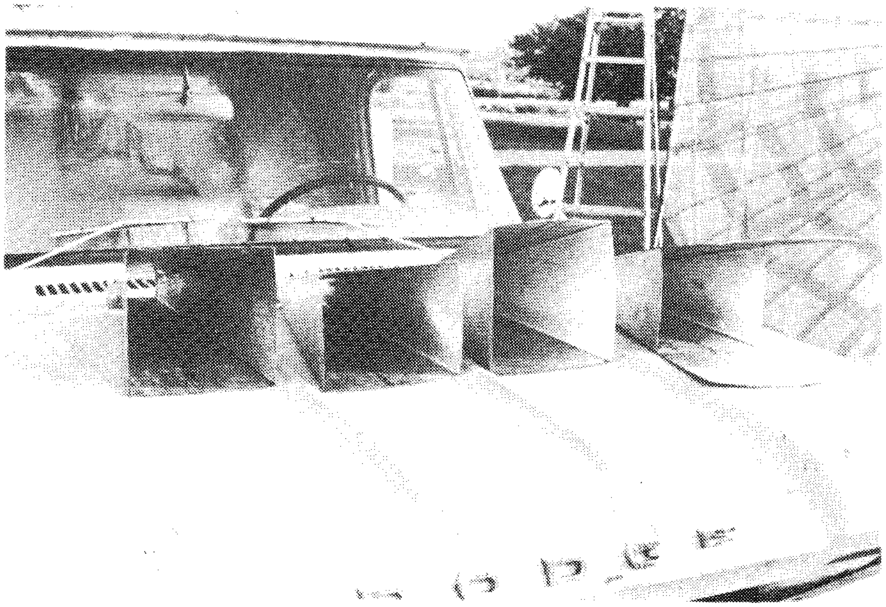
5) Additionally, because the feed point antenna(s) is not directly connected or mounted to the reflector surface (i.e. it is independent and mounts separate from the reflector), and, because the Spherical antenna is capable of intercepting and focusing with high levels of efficency point source signals which are off-bore-sight, it is possible and often desireable to adjust the elevation angle of the reflector surface (this is the angle which the surface 'leans back' from the straight up and down vertical position) to cause the focused energy to focus either higher up (above ground) or lower down (to the ground). Within certain limits to be discussed, you can design your system so that the 'profile' of the reflector surface and the mating feed point antenna can suit your particular installation requirements. We'll look at this in some detail.

The Spherical family of antennas to be described here have been developed by antenna researcher Oliver Swan of Swan Antenna Company in Bisbee, Arizona. Swan's background with Spherical reflectors is considerable; long before the satellite 'challenge' came along Oliver Swan was employing VHF and UHF frequency range Spherical antennas in his many small, rural, cable TV systems located throughout Cochise County in southeastern Arizona. Many cable television systems throughout the North American continent have duplicated Swan's VHF and UHF Spherical antennas for extremely long haul 'off-the-air' reception pickup. References must include the January, February and March 1978 issues of CATJ Magazine and the three part article series entitled "HALF-BOLICS". (Reprints of this three part series are available from CATJ at Suite 106, 4209 NW 23rd, Oklahoma City, Ok. 73107 for a total price of $5.00. Specify 'Half-Bolic Antenna Series' appearing in the above captioned three issues for 1978.)

The Swan Spherical TVRO antennas to be described here have been developed largely by empirical methods. This is especially true with the focus point feed (horn) antenna(s) described. In most text books, while the Spherical reflector surface seems plausible and suitable for this service and in this frequency range, the 'problems' associated with the design of a proper feed antenna to properly 'illuminate' or take signal off of the Spherical reflector surface seem insurmountable. Similar problems faced the designers associated with putting into operation the world's largest 'dish' antenna; the radio astronomy 1,000 foot Spherical antenna located near Arecibo, Puerto Rico. When initially activated and for some eight years thereafter the operators at Arecibo 'limped along' with a total antenna efficency of around 30-40% from the reflector surface; a problem created by the inability at the time to design and build a feed point antenna that would properly illuminate the giant dish. In effect, only a portion (approximately 50%) of the total reflector surface was operating with the early feeds and the 1,000 foot antenna operated more like a 750 foot antenna. The problem was eventually solved of course but this points up the unique design problems associated with Spherical reflector surfaces.



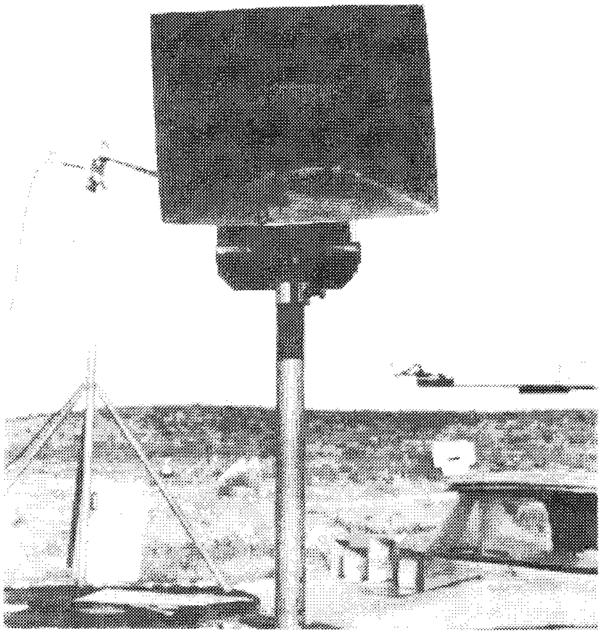
PARABOLIC vs SPHERICAL - Normal parabolic 'dish' antenna is essentially single-bird-at-a-time antenna while Spherical's unique form allows simultaneous reception from numerous satellites spread over up to 40 degrees of 'sky arc'.



EVOLUTION OF FEED HORN design for present generation of high efficiency Spherical antennas is evidenced by this line up of four early models. Version with partially open sides (far right) led to present design.

A basic goal of the feed horn design is to insure that the outer most edges of the Spherical surface are from 15 to 17 dB down reference the 'gain' of the center (or maximum portion) of the feed (horn) antenna. Additionally, in towards the center of the antenna (i.e. away from the outer edges) just 5-8% of the reflector surface width (or height) the 'pattern' of the feed antenna should rise to a point that is no more than 10 dB down from the maximum ('boresighted') gain of the feed (horn) antenna.

Most text books suggest that this cannot be done or if it can be done, it will require exceedingly elaborate machined parts and tolerances (at the 3.7 to 4.2 GHz frequency range) which are in the 1 to 2/1000ths area.



HORN HEAD ON - slight offset tilt (left hand edge is down) is no illusion nor mistake; canted incoming wavefront from birds not due south of you requires adjusting feed horn (probe) to proper polarization match

One textbook (Antenna Engineering Handbook) simply suggests that "...the design is achieved by experimental techniques...". Which is the basic approach followed by innovator Oliver Swan. No claims are made for the total-optimized-performance of the horn feed antenna described here. Improved performance may be 'just a bend of sheet metal away'; and if in fact improvements are discovered, they will be passed along to enthusiasts through the medium of COOP's SATELLITE DIGEST (see last page of manual).

Still, some comfort can be found by critically analyzing the operational characteristics of the present (and herein detailed) Spherical reflector surface plus the horn feed antenna described here. To that end careful measurements have been made of the performance of the Spherical versus both mathematical projections of expected performance in a given location (i.e EIRP area) utilizing an antenna system of known (i.e. measured) gain, and, in side by side comparative testing against both other Spherical antennas and against commercially manufactured parabolic antennas.

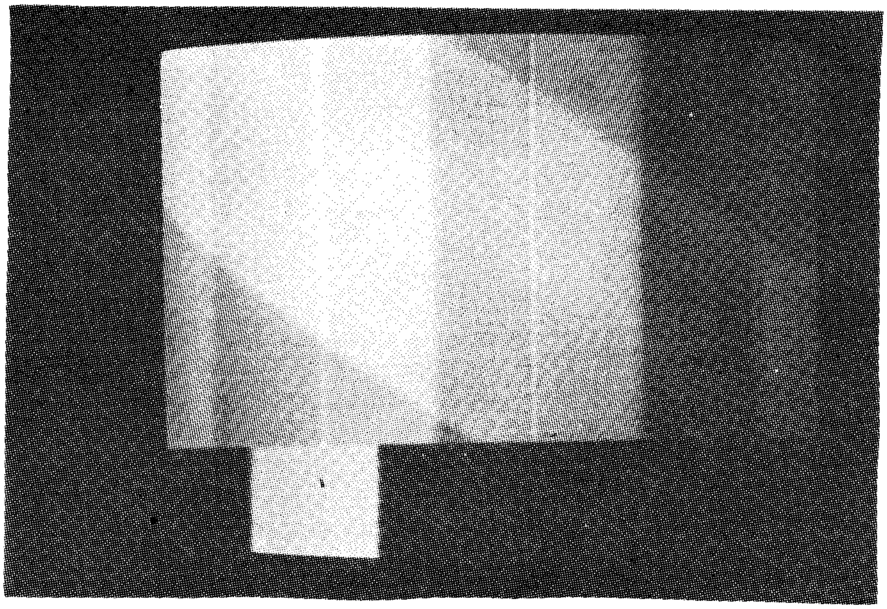
Swan's Spherical antenna test yard includes three separate Spherical 'dishes' measuring 10 feet, 14 feet and 19 feet in size. A 16 foot model has also been constructed and it was subsequently taken to western Texas where its performance was compared directly against a commercial 4.57 meter (15 foot) parabolic antenna.

Test Conditions: In the Bisbee (Arizona) area the EIRP footprints on RCA SATCOM F1 vary from 33.5 dBw forecast (transponder sets (4), 8, 12, (16), 20 and 24, and, 1, 5, 9, 13, 17, 21) to 34 dBw for transponders 2,6,10,14,18 and 22 to 35.5 dBw for transponders 3, 7, 11, (15), (19) and 23.

NOISE FREE RECEPTION from SATCOM FI, transponder 13, through Swan Spherical 14 foot reflector at Bisbee test site.

While both a Microdyne 1100 TVR/VT and a Hughes SVR 461 receiver have been tested at the Swan site the Hughes 461 receiver has been in the most consistent use. A simply connected VOM plugged into an 'AGC monitoring jack' on the 461 allows you to sample the relative signal level present through the antenna/feed horn/LNA and receiver package. As the photos here show, the performance on the 14 foot Spherical reflector (in the footprint area of Bisbee) is above the noise (i.e. sparklies in the trade) using this test system. The LNA is an SCI 120 degree K unit and the 4 GHz energy from the LNA to the SVR 461 receiver runs through around 15 feet of standard RG-8/U coaxial cable. The bottom photo indicates that in the worst case on the 10 foot Spherical reflector the same system produces an image which at least on a static scene (color bars show up noise worse than any other image) there is around 0.5 dB of sparklie noise in the picture. For those people fortunate enough to live in an area with higher EIRP numbers even the ten foot Spherical reflector would produce (impulse) noise free video.

By monitoring the AGC voltage point on the SVR 461 receiver the relative carrier levels for each of the 19 active-with-video transponders on F1 was noted. A mean number of the differences was calculated and from that negative and positive numbers derived based upon whether a transponder indicated higher or lower than the mean number. Several LNAs were tried to insure that LNA variation was not a factor in the measured



SLIGHTEST HINT OF SPARKLIE NOISE appears on perhaps 'backed off' transponder 9 running impulse-noise-sensitive color bar pattern.

results. Here are the results:

1) Horizontal / F1 Antenna Set One (33.5 dBw contour)

Transponder	4	(broken/ no service)
"	8	+0.06
"	12	+0.06
"	16	(no regular service)
"	20	-0.20
"	24	-0.12

2) Horizontal / F1 Antenna Set Two (34.0 dBw contour)

Transponder	2	+0.04
"	6	+0.13
"	10	+0.03
"	14	0.00
"	18	-0.01
"	22	-0.17

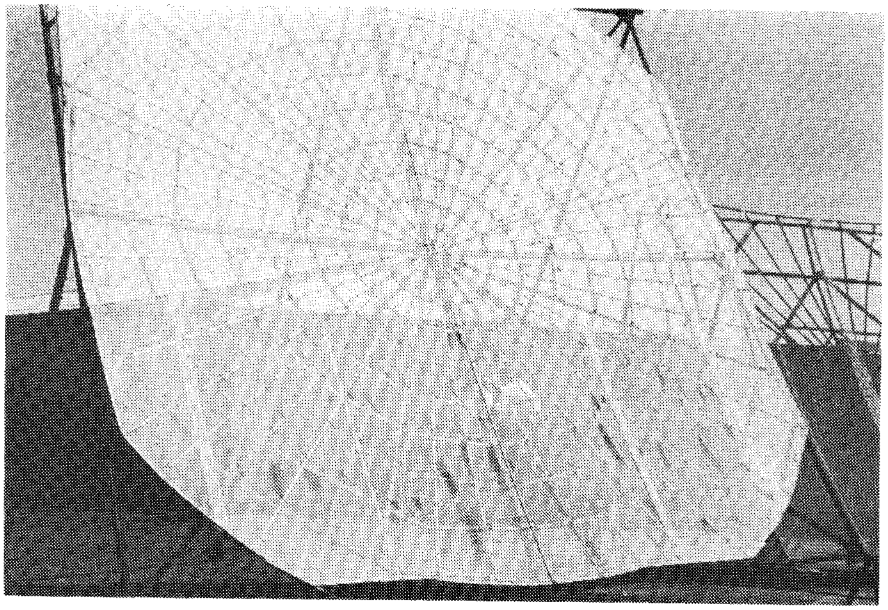
3) Vertical / F1 Antenna Set Three (35.5 dBw contour)

Transponder	3	+0.17
"	7	(no regular service at time)
"	11	+0.20
"	15	(no regular service)
"	19	(no regular service)
"	23	-0.04

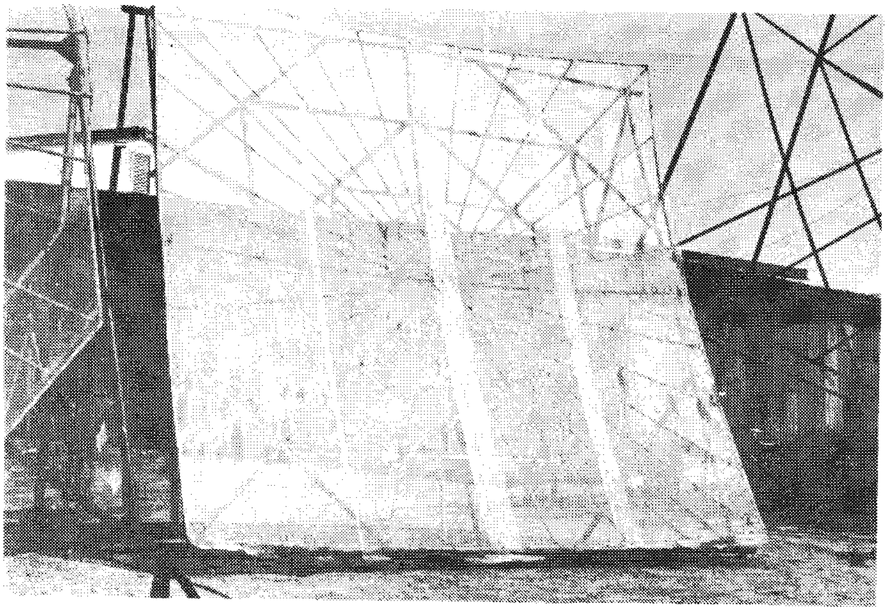
4) Vertical / F1 Antenna Set Four (33.5 dBw contour)

Transponder	1	+0.01
Transponder	5	+0.13
"	9	+0.13
"	13	+0.13
"	17	0.00
"	21	-0.06

From these termed measurements some statement as to the performance of the antenna system can be drawn. Uniformly, without regard to the F1 antenna set nor with the operating parameters of the individual uplinks (i.e. whether they were operating into 'saturation' with their uplink signal) it can be seen that peak system performance appears to be concentrated in the middle of the 3.7 to 4.2 GHz band with a very slight degradation of performance in the lower transponders and a slightly more marked



LOOK CAREFULLY AT 'dark patches' (may appear as 'oily stains' in photo) on reflector surface screen. This indicates small areas where sunlight reflection suggests surface reflection accuracy is slightly out of tolerance.See text page 17.



TEN FOOT SPHERICAL REFLECTOR is considerably less complex, mechanically, than 14 foot version. Note 'oily appearing patches' indicating lack of surface accuracy in bright, direct sunlight reflection measurement.

degradation (reference the 0.00 mean level that typically falls in the transponder 14 to 18 region) on the higher end.

In a direct side by side comparison test conducted by a broadcast station licensee in western Texas, utilizing the 16 foot version of the Spherical, the antenna and Swan supplied feed produced an average increase in carrier level of 1 dB (i.e. C to N improvement) over the 4.57 meter parabolic against which it was directly compared.

Again, there is no statement here as to the absolute performance characteristics of the Spherical antenna as described in this manual. Rather there are these simple statements that given the known (or believed to be accurate) EIRP levels present in southeastern Arizona, and the system electronics noted here, the system is producing high quality video reception.

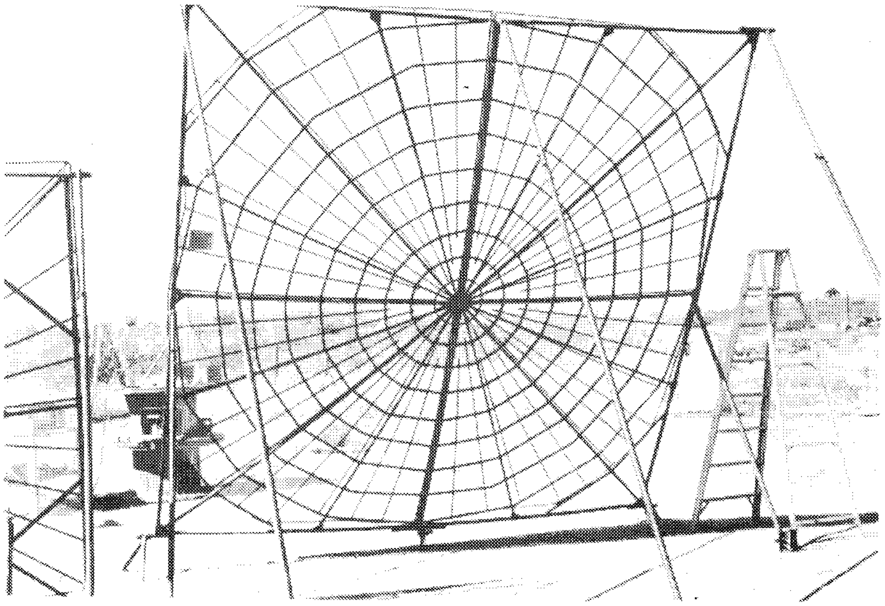
(NOTE: Although some facets of the Swan Spherical antenna plus Swan-designed horn feed antenna may be novel in their design and construction, Swan believes that any attempts to patent the antenna or portions thereof would be a total waste of time and his money in a highly fluid technology that changes by the day and week. He has chosen to enter into limited production of the Spherical design antenna at his own facility near Bisbee and he is currently producing antennas, to order, in the various sizes described here. Your purchase of this Swan Spherical Antenna Manual includes with it the right for you to duplicate, for your own private use, the antenna described here.

Commercial manufacture of this antenna is restricted to those firms with whom Oliver Swan has a working business relationship. At the present time several firms/individuals are in the process of 'tooling up' to produce the Spherical TVRO antenna design on a 'regional basis' under a royalty arrangement with Swan Antenna Company. These 'regional manufacturers' of the Spherical Antenna will service reasonable chunks of the United States (and Canada) in a manner that will insure that most buyer-users will deal directly with a nearby supplier. Individuals or firms interested in becoming part of the 'Spherical TVRO Antenna' manufacturing team are urged to contact Oliver Swan directly (see Appendix in this manual).)

UNDERSTANDING THE DESIGN

The Spherical reflector surface differs from the more well known parabolic reflector surface in that the depth of the curve is considerably lower with the Spherical. This means that as you duplicate the instructions here, you will be able to work with materials (such as steel tubing both square and round) which bends either very slightly or not at

swan spherical



REAR OF 14 FOOT SPHERICAL (surface material on far side) shows bracing and cross bracing technique utilized by Swan to break up surface regions into a multitude of small 'flat' surface areas in achieving overall Spherical contour.

all from end to end. The whole concept may be easier to understand if you think about it in this manner:

a) Every point on the surface of the reflector must be equidistant from corresponding points within the feed horn.

b) Equidistant in this situation means within 1/8th inch (roughly 1/16th of a wavelength at 4 GHz).

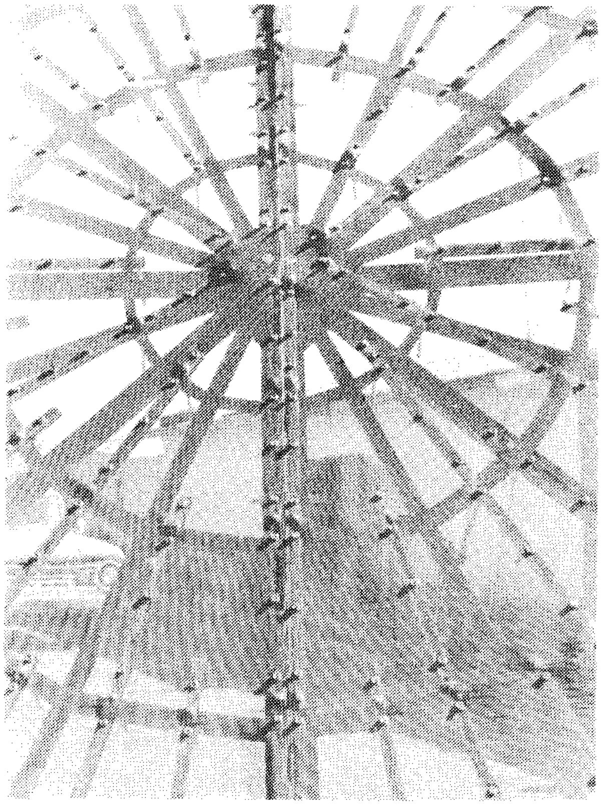
In a true parabolic antenna, the whole surface of the reflector curves. That is, the surface is constantly curving although the amount of curve between two points a couple of inches apart may be very small; say less than the 1/8th inch "tolerance" cited above.

Therefore, it is possible, without sacrificing appreciable amounts of reflector surface 'focusing gain' to break the reflector surface up into a system of triangles, rectangles, squares and other less common geometric shapes whereby within each of these individual surface regions there is no curve at all.

But, when the individual regions are viewed as a whole reflector surface, the reflector surface takes on the required (and within tolerance) degree of 'curvature' to form the necessary parabolic shape.

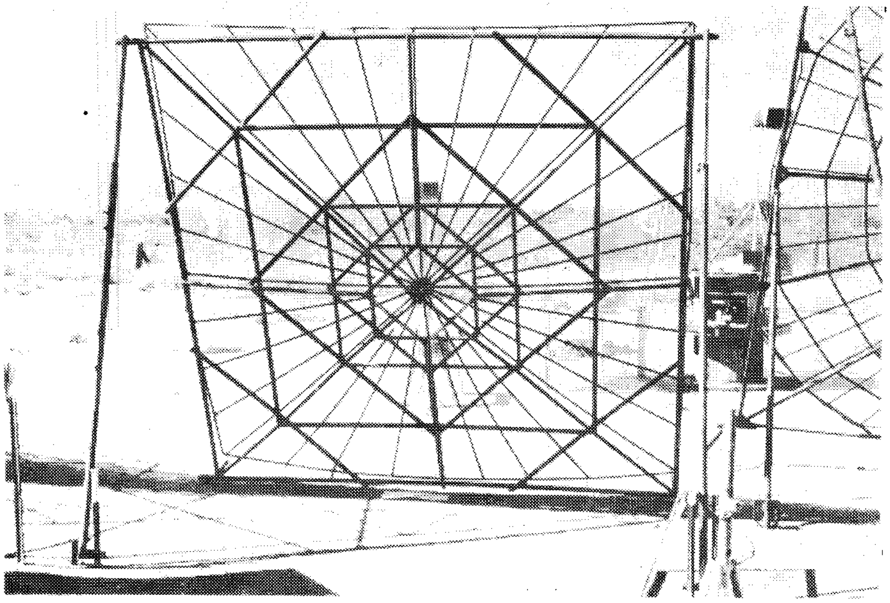
Many of the so-called parabolic antennas offered for CATV accomplish their 'parabolic form' by doing just that; by using flat (i.e. not curved) pieces of metal to form the reflector surface, but by keeping the width and or height of each flat piece small enough that when the sum of all pieces is viewed as a whole surface there is the required degree of curvature to cause the surface to be an effective reflector and focusing device at the 4 GHz signal range.

If one approaches the reflector surface in this manner, the difficulties associated with making metal bend in two directions at once (remember we are dealing with creating the 'inside' of a sphere here; just like the inside of a round ball or a section from a portion of a ball) are far less com-



ALUMINUM WINDOW SCREENING utilized for surfacing is run vertically from top of antenna to bottom in 34 inch wide strips (less overlap region between strips) and held in place with #7 sheet metal screws affixed through screening to ½ inch square tubing members that form contoured Spherical surface.

plex. The builder is not given precise material lists nor templates in this manual simply because the antenna is now in commercial manufacture and some rights must be reserved to Oliver Swan. However careful study of the photos and the drawings, and a full understanding of the principles involved will allow you to create your own structure to support the reflector surface in a manner which will in turn produce high quality results.



REAR OF TEN FOOT SPHERICAL illustrates reduced complexity of framework system. Antenna sits on two collars at base and is incline-tilt supported by a pair of slide adjustable support tubes to top and rear of array.

In that regard the following caveats are offered:

1) Swan has found that if you design your reflector surface support system so that there are no flat surfaces on the final reflector screen larger half the opening of the feed horn 'mouth' you should get near optimum results with the system.

   For temporary reference, the feed horn has a mouth that is 11.2 inches by 8.5 inches (the probe is perpendicular to the 11.2 inch side). This works out to a maximum flat region of approximately 45 square inches of surfacing material. If in your own final reflector surfacing material support system design you end up with no flat surfaces more than 45 square inches in size, you should be in good shape as far as reflector surface accuracy (to an overall Spherical shape) is concerned.

2) The structure must be rigid. As will be noted, the 10 foot version is anchored to the ground at two points while floating collars at the top of the structure allow the 'tilt angle' to be adjusted to both your location and the angle of feed horn 'pick off' desired by you. The 14 foot version, which looks in the photos as if it were rounded at the edges (it is in this particular version but this has no impact upon performance as described), is also anchored to the ground at two points on the lower lip and is then supported two times to the rear at the mid-height point of the edges, and then finally three times at the very top.

   One of the advantages of the screening reflector surfacing is that it will not catch and impound the wind (or most snow and ice) as a solid surface will. This relaxes the requirements for the total impact or force strength of the total assembly but not the requirement that the surface reflector support system be rigid.

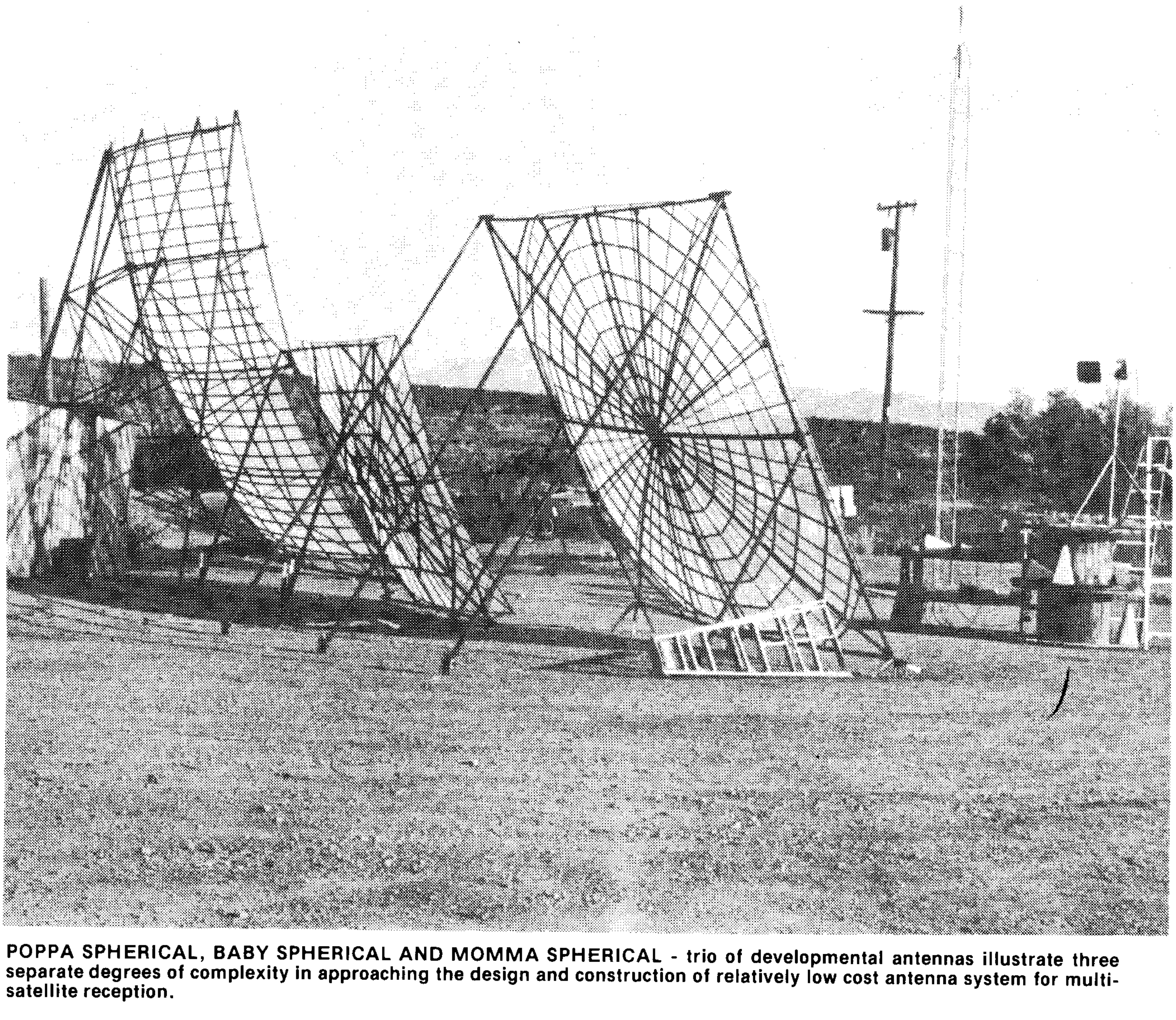
3) The horn feed should be constructed as closely as possible to the design offered here. This design works and works well although as previously noted other designs may prove even better in time. Swan talks of 5/1000th's accuracy on the horn as a 'goal'; it would appear that the two most critical portions of the horn will be

the width and height of the 'mouth opening, and, the opening at the rear (tapered) end of the horn where the flange fits to the flange of the LNA. Obviously the taper should be 'linear' and smooth since the horn forms a 'transition' section of wave-guide for the incoming wavefront(s).

THE PRINCIPLE OF REFLECTION

In a true parabolic antenna every point on the reflector surface is equidistant from both the satellite point-source signal and the focus point feed antenna. The Spherical antenna has similar (but not identical) characteristics.

Experimentation by Swan has shown that the best balance between proper illumination of the reflector surface by the horn feed antenna and the practical design of the horn itself occurs when there is a focal length to diameter (antenna width) ratio of 1.5 to 1. That is, in rough terms, if the antenna is ten feet wide, the focal point will be along a line parallel to the front plane of the antenna out in front of the antenna



POPPA SPHERICAL, BABY SPHERICAL AND MOMMA SPHERICAL - trio of developmental antennas illustrate three separate degrees of complexity in approaching the design and construction of relatively low cost antenna system for multi-satellite reception.

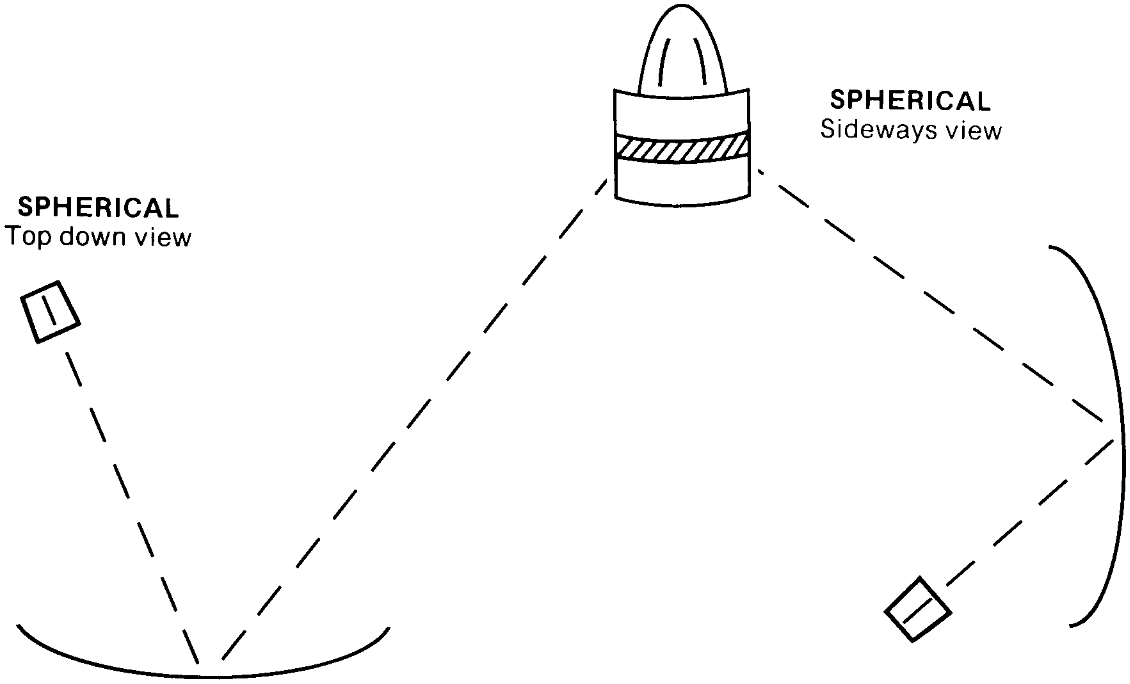
1.5 times the width; or 15 feet in our example. The builder has several choices to make in designing his own antenna system.

1) The size (i.e. gain) of the antenna (the antenna is basically 'square' so the width becomes the height dimension as well)

2) The 'tilt angle' (i.e. the degree off of true vertical (up and down) of the reflector surface determined by deciding where you want the feed point 'plane' to fall above ground)

3) The true bearing of the center line of the antenna (i.e. remember that the Spherical is capable of intercepting with good efficency signals that span an in-sky orbit arc of up to 40 degrees; the 'bore-sight' bearing of the antenna can be adjusted prior to installation to intersect the middle of that portion of the orbit arc which will give you coverage (with appropriate feed re-positioning) of the largest number of satellite (point sources)).

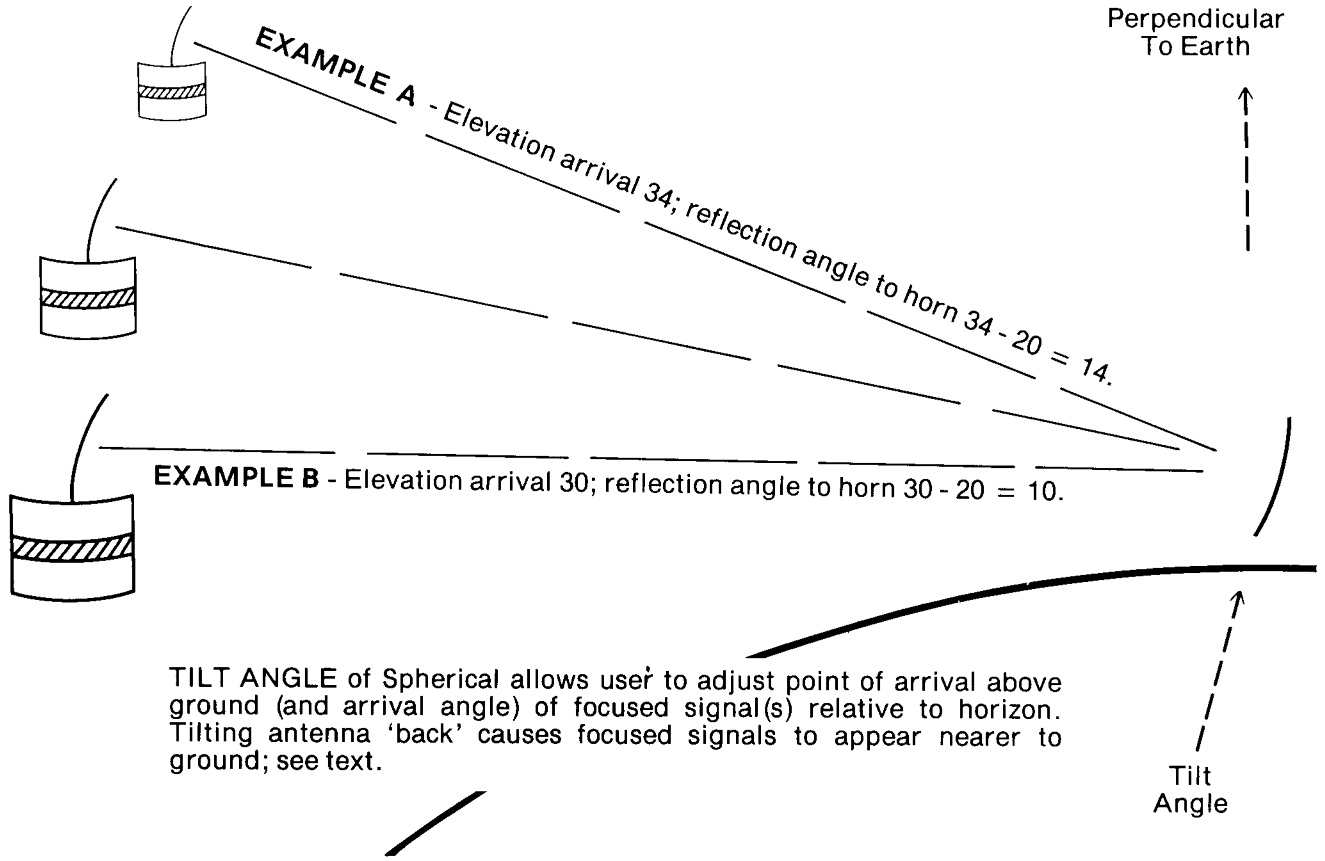
Size is simply a matter of what you can handle in your physical quarters and how much gain you need (when mated with the LNA you have chosen and the receiver you have chosen). As noted, the ten foot version provides very high quality pictures when mated with a 120 degree K LNA and a receiver of typical specifications (i.e. the Howard Terminal receiver is comparable to the Hughes SVR 461 receiver used in Swan tests). The fourteen foot version, on the other hand, will provide most if not all of the margin normally recommended



PRINCIPLE OF SPHERICAL REFLECTION/FOCUSING - surface of Spherical curves in both directions at once (although as text notes this may be accomplished with series of small 'flat areas' end to end, each slightly curved from those around it) producing focusing of reflected wavefronts to central point that lys along line parallel to surface tangent, offset from dead-on (bore-sight) of antenna by amount equal to offset of arriving angle; but in opposite direction along antenna's focal-line'.

for commercial (CATV/MATV etc.) installations (the FCC urges commercial installations to maintain a 3 dB 'excess' carrier to noise ratio above the noise threshold point of the receiving system if the systems are to be licensed by the Commission). These general statements refer to EIRP footprints in the 34 to 37 dBw region as found in the Bisbee area. For footprints below the 34 dBw region, the fourteen foot version will provide useable signal recovery down to the 31.5 to 32 dBw region. For footprints in the 29 dBw region a Spherical in the 18-20 foot size region would be recommended.

Tilt angle is an interesting exercise in mobility. The Spherical, unlike its cousin the parabolic, does not have to boresight the satellite; and in fact you lose very little signal gain by being 'off bore sight' by as much as + or - 20 degrees (i.e. left or right as in azimuth, or, by the same amount in elevation; up and down). The ability to reflect and focus energy that arrives left or right off of bore sight is the primary reason why the Spherical is able to look at such a (relatively) wide orbit arc (40 degrees) effectively. Keep in mind that the Spherical's "wide angle look" works in both planes; i.e. left and right as in azimuth and up and down as in elevation. Since the Spherical does not have to bore sight the bird(s), you can select a tilt angle that will place the reflected and focused signal(s) at a convenient height above ground for you to install the feed horn antenna(s). In Swan's case, he has chosen a tilt angle of 26 degrees which results in his feed antennas being typically 5 to 10 feet above ground and in turn tilted slightly down towards the ground. The slight forward tilt on the feed horn is useful as a way to keep rain, snow and moisture from collecting in the horn (and subsequently in the cavity and around the input probe on the LNA) since all moisture entering the horn or collecting there runs down and out to the ground below.

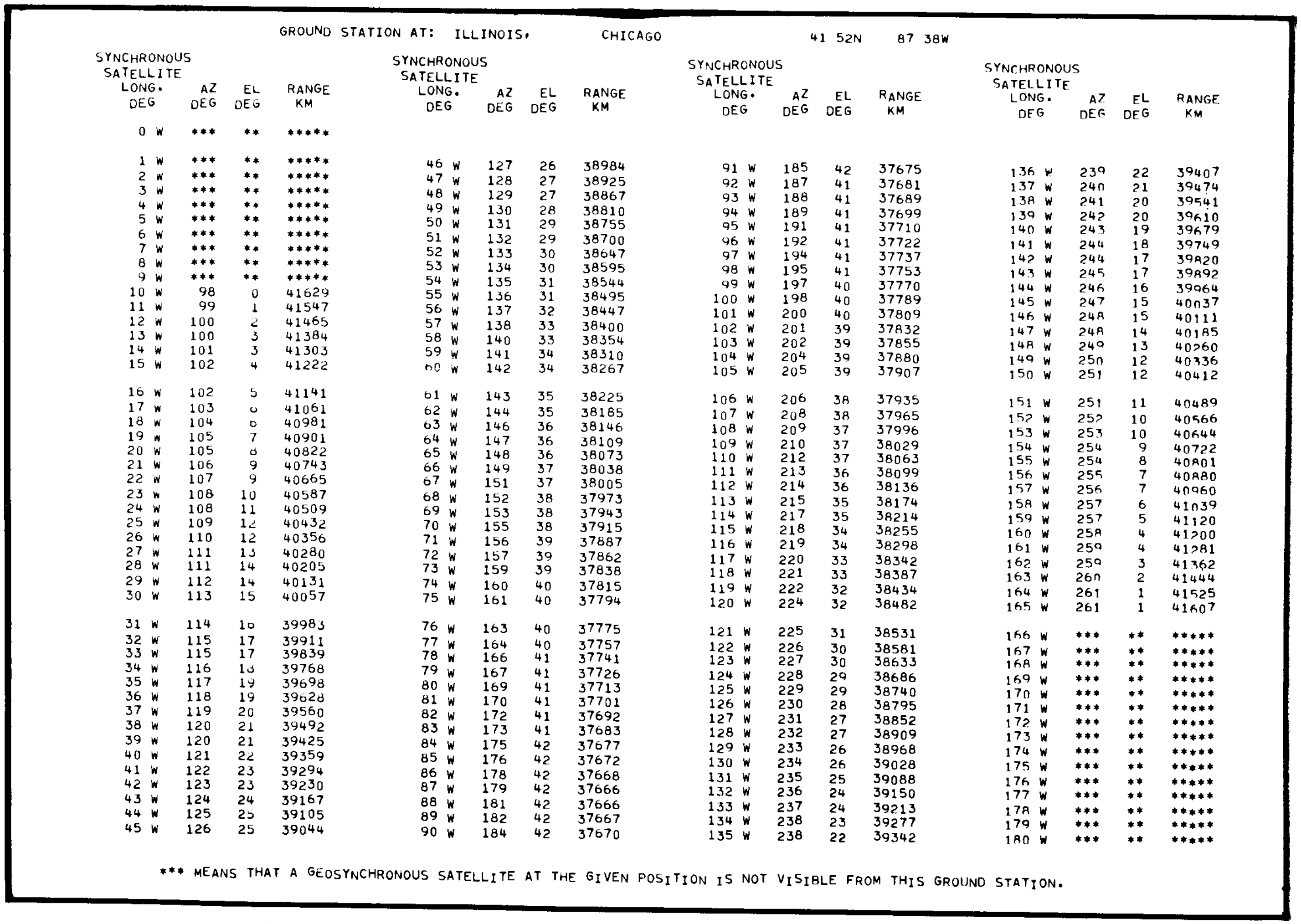

EXAMPLE A - Elevation arrival 34; reflection angle to horn 34 - 20 = 14.
Perpendicular To Earth
EXAMPLE B - Elevation arrival 30; reflection angle to horn 30 - 20 = 10.
Tilt Angle

TILT ANGLE of Spherical allows user to adjust point of arrival above ground (and arrival angle) of focused signal(s) relative to horizon. Tilting antenna 'back' causes focused signals to appear nearer to ground; see text.

swan spherical

Every serious builder of a satellite reception system should have a full set of references indicating to him where in the sky the various satellites are located. One method of computing the satellite elevation angles and their azimuth heading for a given location is described in the March 1978 issue of QST Magazine (see Locating Geosynchronous Satellites, page 23). An even easier system than computing the elevation and azimuth angle for each satellite on your orbit horizon is to send $1.00 plus a large (9 x 12 inch) stamped envelope (28 cents in postage) to: Bill Johnston, 1808 Pomona Drive, Las Cruces, N.M. 88001 and include your exact geographic coordinates (longitude and latitude to the nearest minute). What you will receive back from Johnston is a detailed IBM 360 print out of the full orbit belt sky from your location; indicating (as the partial example below shows) the degrees of azimuth (reference true north), degrees of elevation (reference your horizon) and the range in kilometers to the satellite from your location. With this reference data you will be better able to select a tilt angle for your location and a true bearing for your location.

True bearing is simply a case by case decision of where you want your 40 degree wide slot to fall on the orbit belt. For example, if you recognize that most of the present operation of U.S. and Canadian geostationary satellites falls between 99 degrees west (WESTAR I) and 136 degrees west (the after-FIII-launch position of the present FI), you note that there is a 37 degree arc already established in which there are two WESTAR satellites, three active or usually active ANIK (Canadian) satellites, two now (and three soon) RCA SATCOM satellites and one COMSTAR satellite. This suggests that if you bisect



GROUND STATION AT: ILLINOIS, CHICAGO 41 52N 87 38W

SYNCHRONOUS SATELLITE LONG. DEG	AZ DEG	EL DEG	RANGE KM	SYNCHRONOUS SATELLITE LONG. DEG	AZ DEG	EL DEG	RANGE KM	SYNCHRONOUS SATELLITE LONG. DEG	AZ DEG	EL DEG	RANGE KM	SYNCHRONOUS SATELLITE LONG. DEG	AZ DEG	EL DEG	RANGE KM
0 W	***	**	*****												
1 W	***	**	*****	46 W	127	26	38984	91 W	185	42	37675	136 W	239	22	39407
2 W	***	**	*****	47 W	128	27	38925	92 W	187	41	37681	137 W	240	21	39474
3 W	***	**	*****	48 W	129	27	38867	93 W	188	41	37689	138 W	241	20	39541
4 W	***	**	*****	49 W	130	28	38810	94 W	189	41	37699	139 W	242	20	39610
5 W	***	**	*****	50 W	131	29	38755	95 W	191	41	37710	140 W	243	19	39679
6 W	***	**	*****	51 W	132	29	38700	96 W	192	41	37722	141 W	244	18	39749
7 W	***	**	*****	52 W	133	30	38647	97 W	194	41	37737	142 W	244	17	39820
8 W	***	**	*****	53 W	134	30	38595	98 W	195	41	37753	143 W	245	17	39892
9 W	***	**	*****	54 W	135	31	38544	99 W	197	40	37770	144 W	246	16	39964
10 W	98	0	41629	55 W	136	31	38495	100 W	198	40	37789	145 W	247	15	40037
11 W	99	1	41547	56 W	137	32	38447	101 W	200	40	37809	146 W	248	15	40111
12 W	100	2	41465	57 W	138	33	38400	102 W	201	39	37832	147 W	248	14	40185
13 W	100	3	41384	58 W	140	33	38354	103 W	202	39	37855	148 W	249	13	40260
14 W	101	3	41303	59 W	141	34	38310	104 W	204	39	37880	149 W	250	12	40336
15 W	102	4	41222	60 W	142	34	38267	105 W	205	39	37907	150 W	251	12	40412
16 W	102	5	41141	61 W	143	35	38225	106 W	206	38	37935	151 W	251	11	40489
17 W	103	6	41061	62 W	144	35	38185	107 W	208	38	37965	152 W	252	10	40566
18 W	104	6	40981	63 W	146	36	38146	108 W	209	37	37996	153 W	253	10	40644
19 W	105	7	40901	64 W	147	36	38109	109 W	210	37	38029	154 W	254	9	40722
20 W	105	8	40822	65 W	148	36	38073	110 W	212	37	38063	155 W	254	8	40801
21 W	106	9	40743	66 W	149	37	38038	111 W	213	36	38099	156 W	255	7	40880
22 W	107	9	40665	67 W	151	37	38005	112 W	214	36	38136	157 W	256	7	40960
23 W	108	10	40587	68 W	152	38	37973	113 W	215	35	38174	158 W	257	6	41039
24 W	108	11	40509	69 W	153	38	37943	114 W	217	35	38214	159 W	257	5	41120
25 W	109	12	40432	70 W	155	38	37915	115 W	218	34	38255	160 W	258	4	41200
26 W	110	12	40356	71 W	156	39	37887	116 W	219	34	38298	161 W	259	4	41281
27 W	111	13	40280	72 W	157	39	37862	117 W	220	33	38342	162 W	259	3	41362
28 W	111	14	40205	73 W	159	39	37838	118 W	221	33	38387	163 W	260	2	41444
29 W	112	14	40131	74 W	160	40	37815	119 W	222	32	38434	164 W	261	1	41525
30 W	113	15	40057	75 W	161	40	37794	120 W	224	32	38482	165 W	261	1	41607
31 W	114	16	39983	76 W	163	40	37775	121 W	225	31	38531	166 W	***	**	*****
32 W	115	17	39911	77 W	164	40	37757	122 W	226	30	38581	167 W	***	**	*****
33 W	115	17	39839	78 W	166	41	37741	123 W	227	30	38633	168 W	***	**	*****
34 W	116	18	39768	79 W	167	41	37726	124 W	228	29	38686	169 W	***	**	*****
35 W	117	19	39698	80 W	169	41	37713	125 W	229	29	38740	170 W	***	**	*****
36 W	118	19	39628	81 W	170	41	37701	126 W	230	28	38795	171 W	***	**	*****
37 W	119	20	39560	82 W	172	41	37692	127 W	231	27	38852	172 W	***	**	*****
38 W	120	21	39492	83 W	173	41	37683	128 W	232	27	38909	173 W	***	**	*****
39 W	120	21	39425	84 W	175	42	37677	129 W	233	26	38968	174 W	***	**	*****
40 W	121	22	39359	85 W	176	42	37672	130 W	234	26	39028	175 W	***	**	*****
41 W	122	23	39294	86 W	178	42	37668	131 W	235	25	39088	176 W	***	**	*****
42 W	123	23	39230	87 W	179	42	37666	132 W	236	24	39150	177 W	***	**	*****
43 W	124	24	39167	88 W	181	42	37666	133 W	237	24	39213	178 W	***	**	*****
44 W	125	25	39105	89 W	182	42	37667	134 W	238	23	39277	179 W	***	**	*****
45 W	126	25	39044	90 W	184	42	37670	135 W	238	22	39342	180 W	***	**	*****

*** MEANS THAT A GEOSYNCHRONOUS SATELLITE AT THE GIVEN POSITION IS NOT VISIBLE FROM THIS GROUND STATION.

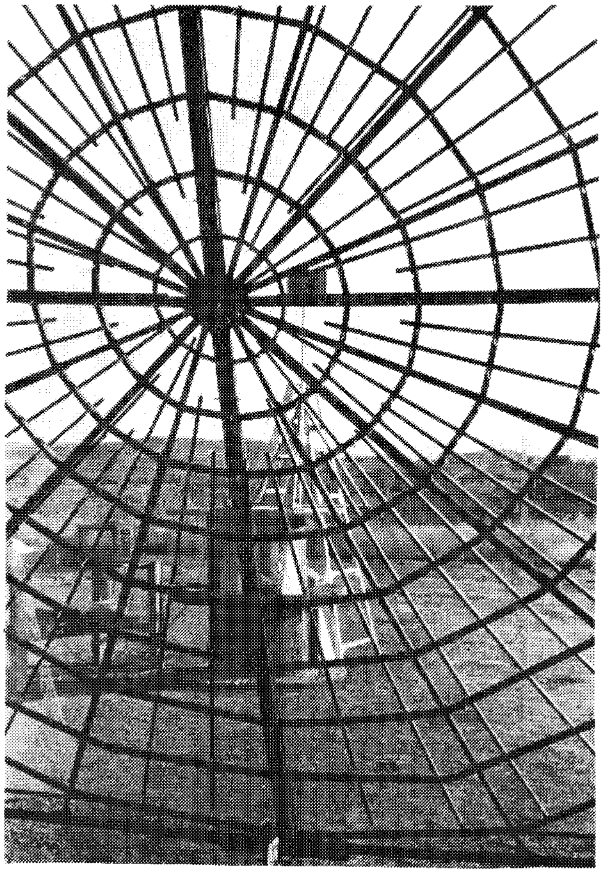
the orbit belt between 99 degrees west and 136 degrees west from your particular location (remember the orbit belt 'moves around the sky' for different locations in North America and you will have to determine accurately your own azimuth headings plus elevations for the belt from your location), you will have at least one format for a full-use Spherical system. In our example, the center of the Spherical would fall on the orbit spot at 117.5 degrees west (SATCOM II is at 119 degrees west while ANIK III is at 114 degrees west); i.e. this would be your bore-sight-to center point in the sky.

CONSTRUCTION OF THE SURFACE/FRAMING

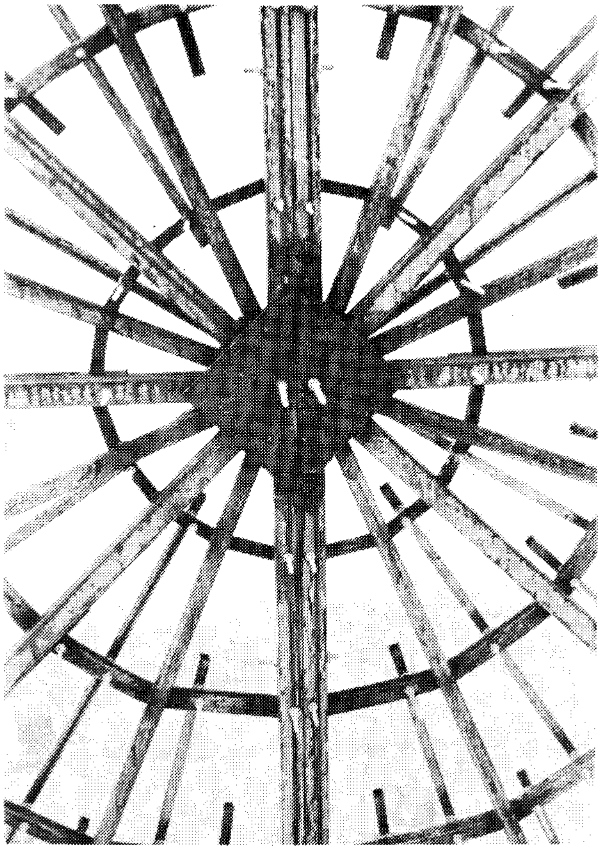
Because this manual does not give detailed step by step construction layouts for the framework (as noted, something must be reserved to designer Oliver Swan for his commercial manufacture of these antennas), you will have to do some sketching and planning on your own to derive the exact framework for your own Spherical. There are these suggestions:

1) Make certain that the layer of the framework to which the reflective material will ultimately be attached is adjustable. Several photos on the next page show how Swan has accomplished this.

   The outer perimeter of the antenna frame is 1 or 1.5 inch OD steel pipe. This provides a 'square' against which all of the other support pieces can be secured, and, it also provides a 'slip joint' of a sort by which you can adjust the tilt angle by using slightly larger (ID) pipe on the ground support (bottom) and the angular supports



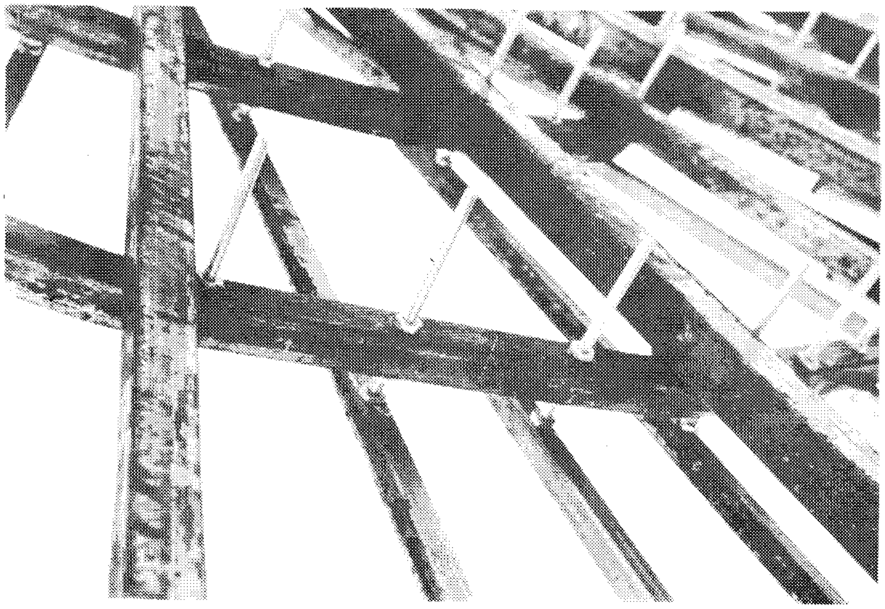
THROUGH THE SPHERICAL - screen mesh reflection surface is barely visible as we look through the 14 foot reflector from rear towards feed horn antenna (visible just above horizontal bar, above center).



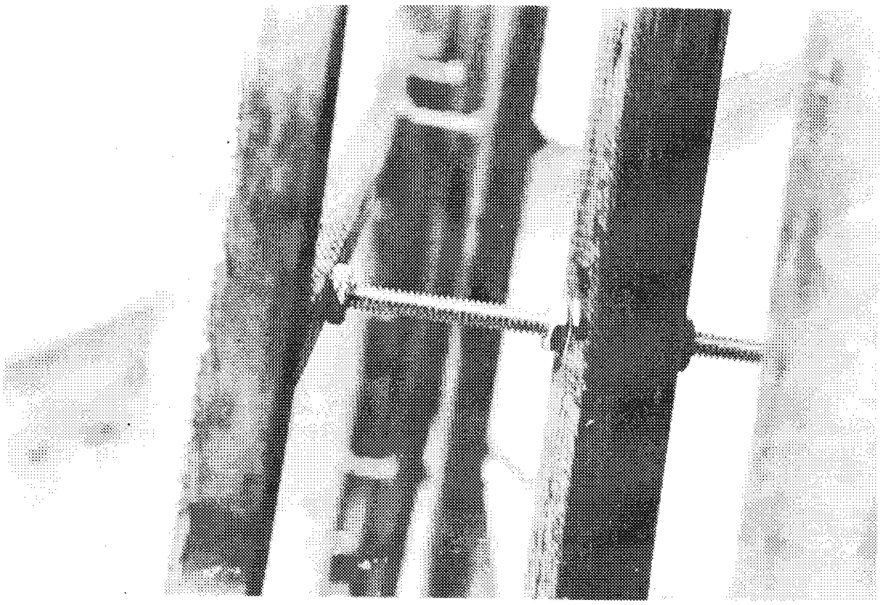
IDENTICAL HALF SECTIONS are bolted together along middle vertical line. Construction on this 14 foot Spherical is largely along welded steel fabrication approach although bolt-joined aluminum or other techniques would work just as well.

at the top of the frame as it mounts to the diagonally placed ground braces.

2) All holes for mounting of the adjusting screws (typically 10:24, 4 inches long; nearly 1,000 in all required) are pre-drilled into the layer of support 'tubes' (1/2 inch square tubing in the Swan model) prior to assembly. Similarily, the holes for the number 7 self tapping metal screws which secure the mesh/reflective surface to the support tubes are also pre-drilled.



LAYER OF SQUARE STEEL TUBING make up framework. Backmost square stock is 1 inch, next 'ring' in is ¾ inch and final inside set, supported by 10:24 adjusting screws to create Spherical contour is ½ inch square stock.



SHAPING THE CONTOUR - 10:24 machine screws (bolts) feed from front surface of ½ inch square stock into ¾ inch stock. Nuts adjust Spherical contour to desired shape using taunt measuring 'wire' stretched to surface from radius point.

The reflective material can be normal 1/8th inch opening (nominal) aluminum window screen (nylon screen is NOT reflective to 4 GHz energy!) or you might investigate #8 mesh, 279A galvanized after woven, from City Wire & Cloth Co., 3706 Avalon Blvd., Los Angeles, California (90011); (213-232-5166). The #8 mesh is stouter than normal window screen, it has better rigidity and all cross wire connections are welded and then the screen is galvanized. It takes around $25 in normal window screen to surface the antenna (14 foot version, using 34 inch wide material) and the #8 mesh typically sells for around 15 cents per square foot (comes to about $30 for a 14 foot by 14 foot surface). In both cases you may have to buy a larger quanity than you need to get the prices quoted which suggests several people pooling their buying efforts for the reflective surfacing.

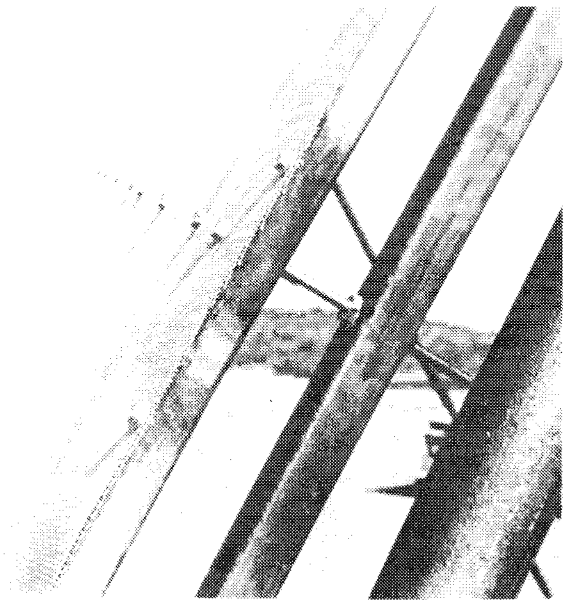
3) The surface must be taunt and smooth. This requires considerable care during surfacing. The photo on page 8 shows one way you can determine (after the fact unfortunately) whether your surface is reasonably smooth; by positioning yourself in line between a bright solar (sun) source and the screen you can see the light reflections from the aluminum screen surface. Where the screen is out of tolerance (relative to being properly contoured) the sun's rays will not reflect in your direction and you will see 'dark spots' on the surface. These dark spots indicate 'bubbling' in the surface at these points. On a properly (i.e. perfectly) surfaced reflector, you would see no 'dark islands' in a sea of reflected brilliance.

The minute variations in the accuracy of the reflector surface are most dangerous as a cumulative loss. Repeated errors, encompassing large physical areas on the surface, will reduce the realizeable gain of the reflector. Smaller errors limited to relatively small regions (i.e. no greater than 50% of the squared space represented by the opening of the feed horn) will usually be compensated for by the horn itself.

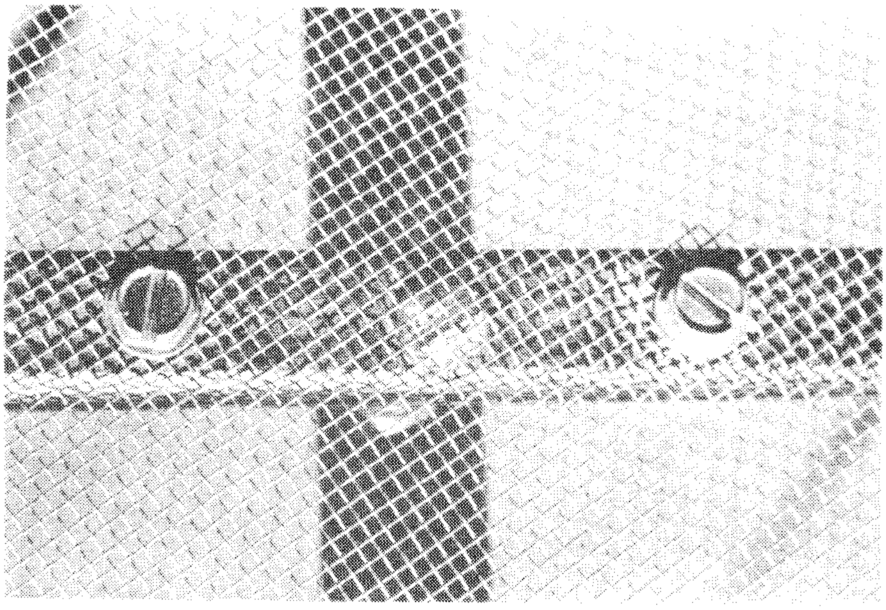
4) The antenna reflector can be constructed in sections; a ten foot reflector for example can consist of two ten foot tall by five foot wide surfaces joined together (with care) in the middle vertical joint line. A 14 foot reflector can consist of four identical sections 7 feet high by 7 feet wide, joined along both vertical and horizontal 'center lines'.

However, the more pieces you break the antenna up into, the more you increase your chances of error in the overall reflector surface accuracy.

5) The # 7 sheet metal screws (chosen because they fit into holes drilled with a 1/8th inch bit) are typically spaced at 3.25 inch intervals along the strut supports. Where a 10:24 machine screw (bolt) is on the surface of the strut for reflector surface adjustment, a #7 metal screw is located 3/4 inch either side of the head of the screw as shown above.



REFLECTOR SCREEN IN PLACE on contoured surface. Screening material is attached with #7 sheet metal screws mounted into holes pre-drilled before actual assembly of antenna got underway.



REFLECTIVE SCREEN TIED DOWN - #7 sheet metal screws located approximately ¾ inch either side of 10:24 Spherical adjusting bolt anchor surface in place on ½ inch square stock.

CALCULATING THE SURFACE AND CURVE

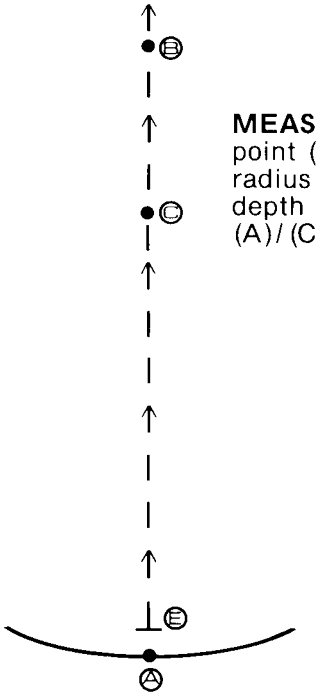
The first step is to determine the bore sighting of the antenna desired (see page

15 here). Drive two stakes in the ground; one representing the center of the antenna (A - below) and another representing the radius point for the Spherical surface area chosen (B - below). The (A) - (B) 'line' should be a bore-sight line for the center of the Spherical surface to the point southwest of you (North America assumed) that represents the center of the portion of the orbit arc you have chosen.

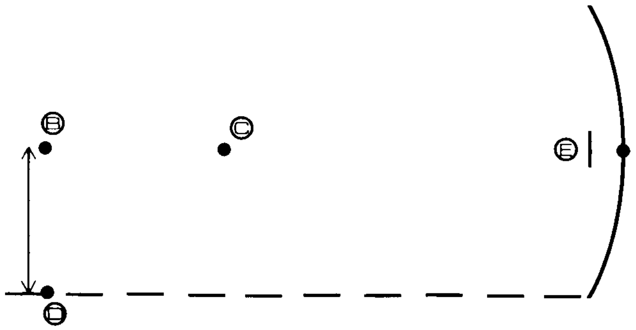
Using the radius point as a measurement dead-man then proceed to mark off your Spherical 'arc' on the ground left and right of the (A) stake that represents the center of the reflector surface. Use a high quality solid steel wire (not stranded as it will stretch under tension!) pulled very taunt to locate the actual arc of the base of the Spherical surface.

The radius point will be used throughout construction and adjustment so it should be permanent and well secured. Swan has developed a spring loaded tool that he uses to check the adjustment of the 10:24 screws that bring the Spherical reflector into tolerance (see photos page 20). Securing the solid steel wire at the radius point at a height that represents the height above ground for an incoming satellite signal if there were a satellite located directly on bore-sight of the antenna, the steel wire is then stretched towards the reflector surface (this is typically at a downward angle since the elevated radius point where the steel wire secures is substituting for an incoming satellite signal arriving at the proper angle). When the spring loaded tool grasps the rear of the strut where the reflector surfacing material will later secure, the spring tension is adjusted by adjusting the 10:24 adjusting screws so that

MEASUREMENTS - 10' will have 30' radius point (A)/(B), 15' focal point (A)/(C) and approximately 6" depth (A)/(E). 14' will have 42' radius point (A)/(B), 21' focal point (A)/(C) and approximately 8" depth (A)/(E). 16' will have 48' radius point (A)/(B), 24' focal point (A)/(C) and approximately 10" depth.



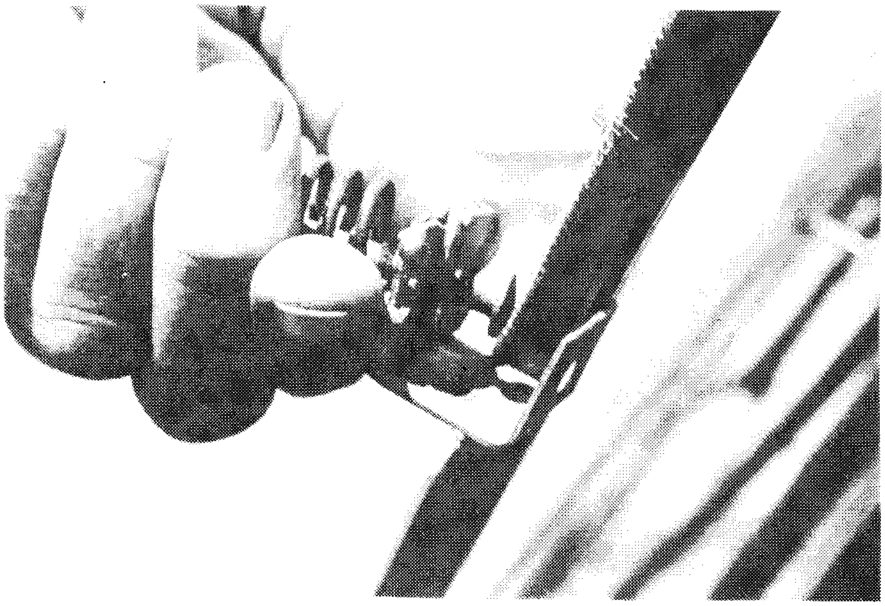
ALIGNMENT — Stake bore-sight line (A)/(B). (A) is center and back-most portion of Spherical surface. (B) is radius point. (C) is focus point.



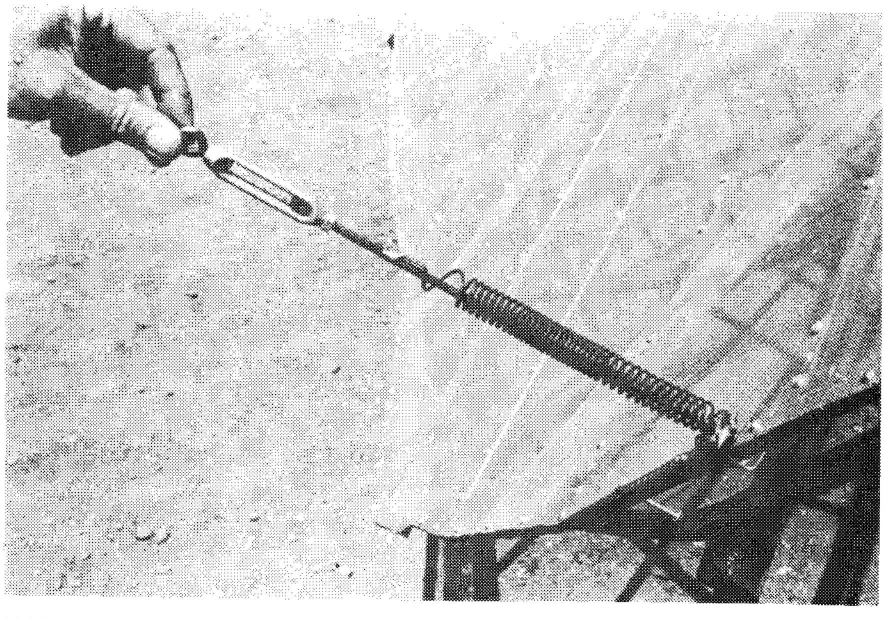
IF ANTENNA has field-adjustable tilt angle built-in, keep Spherical surface vertical (use Inclinometer) uintil surfaced; (B) to (D) height is 1/2 Spherical height. Radius measuring wire would secure at (B).

the spring loaded end of the tool fits up snugly against the front (surfacing side) of the strut framework.

Note: This is all done prior to surfacing; the full surface area must be brought into tolerance, using some method of insuring that the distance from the radius point to the surface area is identical (+/- 0.1 " desireable) at all points on the surface area. Once this is completed, the surfacing material is placed onto the struts.



MEASUREMENT TOOL snaps with lip behind ½ inch square stock; opposite end (see next photo) is connected via taunt solid steel wire to radius point from which all surface measurements are made.



HAND SIMULATES pullof taunt steel wire towards redius measurement reference point. 10:24 bolts (nuts) are adjusted using tool's spring loaded front-of-antenna clip to indicate when the Spherical is properly adjusted at that measurement location.

FINDING THE FEED POINT

The focus points for the various birds within your chosen orbital arc will all be along a line parallel to the plane of the Spherical reflector surface.

However, they will vary in height above ground in proportion to their height above your horizon. A satellite located along your bore-sight (most will not have a satellite exactly on bore-sight) will appear on the line from the center of the surface to the radius point. The focal plane 'line' ('line' being used here to represent the plane of the focal points for the different birds) will be 1.5 times the width of the reflector in front of the Spherical surface. For a ten foot reflector, the focal plane line will be 15 feet in front; for a 14 foot, 21 feet in front and so on.

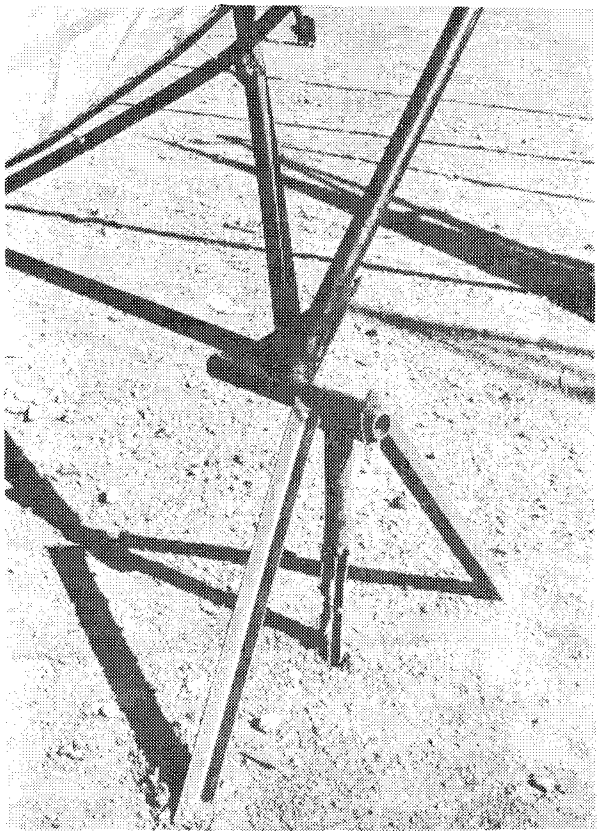
Swan has driven long nails into the ground to mark the locations where the feed horn tripod is situated for each satellite. Because the height above ground to the lower lip of the feed horn varies left and right of your bore-sight center as a function of the orbit belt arc dropping lower and lower to the horizon left and right of bore-sight, some method of adjusting the height of the horn above ground must also be included in the system. A simple telescopic mount, on a tripod, with a hand adjusted set screw is adequate.

The focal point has been variously described as a 'point' or 'the size of a ping-pong ball'. Using a protractor and a sighting tool, the initial 'finding the bird' sequence goes as follows:

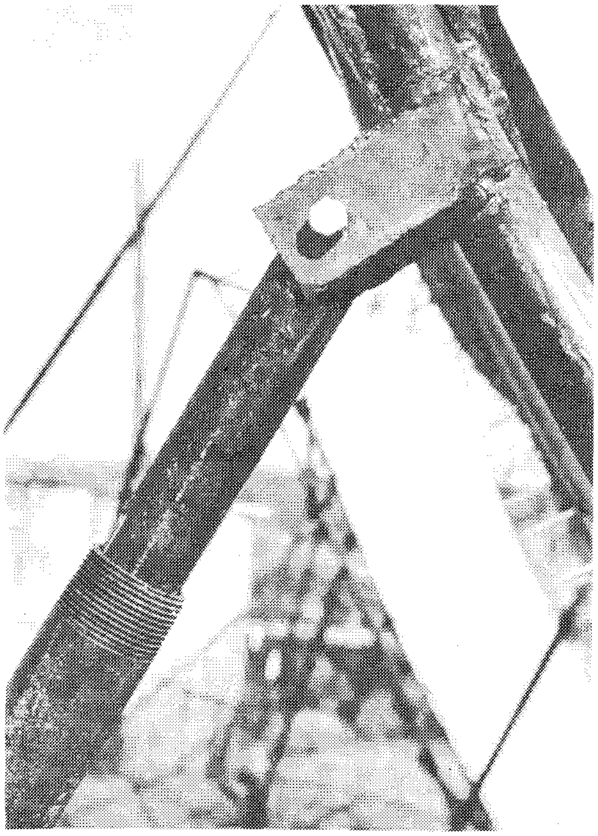
1) 'Sight' the incoming angle from the desired satellite. There will be both an elevation angle and an azimuth angle involved. The Spherical reflector will reciprocate the incoming azimuth angle; i.e. a satellite off bore-sight to the 'left' (as you stand before the reflector and face towards the satellite) will appear off bore-sight to the right, along the focal plane 'line'.

2) The incoming elevation angle of the downlink satellite signal interplays with the tilt angle of your Spherical surface to produce a 'tilted angle' for the feed horn. By tilting the reflector surface 'back' the focused satellite signal rises above ground from where it would be if the reflector surface was exactly perpendicular with the ground.

3) You can approximate the incoming angles on paper, work out a 'ball park area' where the signal from that bird should focus and then start with the feed horn outer lip (i.e. the widest point as it faces to the reflector surface) at that point. Note that the feed horn will point squarely back at the reflector only for a satellite that would be on bore-sight; that it cants off center slightly for signals left and right of bore-sight in a reciprocal nature.



THREE LEGGED GROUND MOUNT consists of rods driven into hard earth, with a pipe collar (horizontal and welded to three ground rods) supporting smaller horizontal piece of pipe welded to bottom corner of frame. This allows antenna inclination to be adjusted.

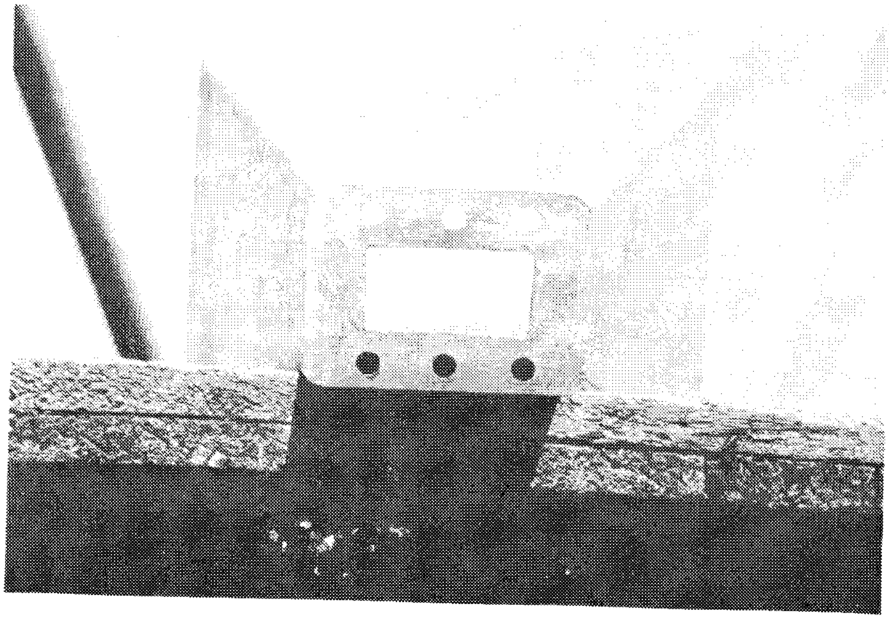


FLOATING 'HINGE' AT TOP OF BACK BRACE - back support to driven ground rod 'hinges' on through-bolt and overall length adjusts with sliding pipe (pipe into pipe) that is held in desired position with set screw welded into place on back side of pipe.

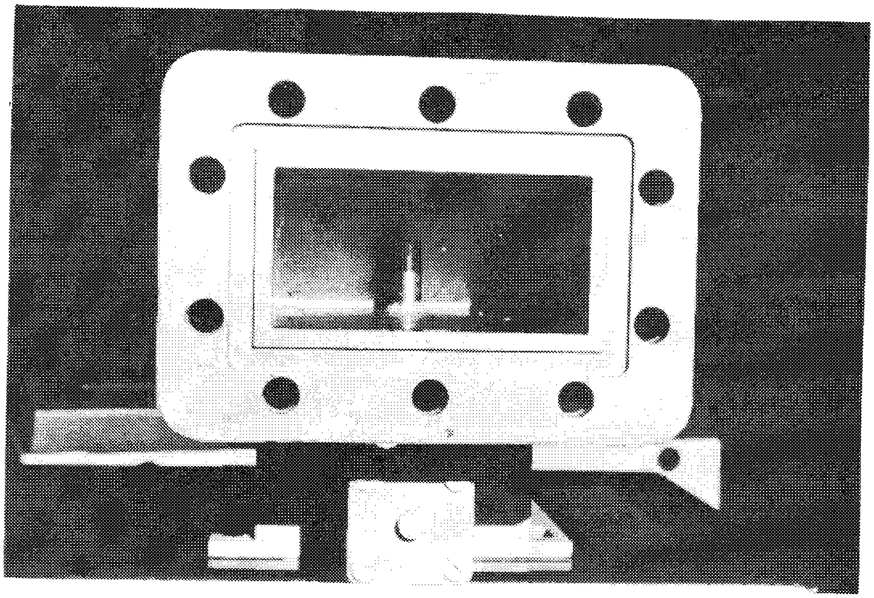
It may take several hours to find the first bird signal but once you get the hang of it the process becomes repeatable in just minutes of search time.

THE FEED HORN

The horn is constructed according to the drawings on page 23. The material is Zinc plated steel, 26 gauge. This material will take normal solder (with sufficent heat supplied) and you will be carefully soldering the seams. It has been suggested that the efficency of the horn might be improved by plating it with some material such as silver which has lower resistance to the flow of microwave energy currents. With the cost of silver and the fact that the horn would have to be first plated with copper to take the silver top layer, it seems likely that silver plating is a waste of good money. In the best case the horn might pick up 0.25 dB of efficency.



FEED HORN FLANGE is designed to bolt directly to mating flange plate on low noise amplifier. 'Fit' between both flanges must be snug all around to prevent 4 GHz energy from 'leaking' out through cracks.



MATING FLANGE PLATE ON typical (SCI) low noise amplifier. Probe set back inside of input cavity is device that couples satellite signal energy out of the input cavity and into first low noise transistor amplifier stage in LNA.

The horn has precise dimensions (as shown) and it mates with a homemade flange directly to the input flange on a standard LNA. One of the most important warnings here is that the surface to surface contact between the LNA flange and the horn flange must be tight and smooth. If the horn flange does not fit tightly, build the surface back up with solder and then use a half round file to smooth it back down. Microwave energy likes to 'leak' out of flange connections and such energy leaking is energy that is lost to the system. There are ten bolts securing the LNA flange to the feed horn flange. Use all ten bolt holes and make sure the bolts are tight. You can lose a dB very quickly here by not having a smooth, tight fitting, flat surface to flat surface contact.

The horn starts out as a flat piece that is cut to the dimensions shown on page 23. Layout the full horn on the zinc plated steel and use a sharp tool to carefully scribe the fold lines as well as the cut lines. Check and recheck the layout for accuracy before cutting.

23" HORN for focal length/diameter (f/d) of 1.5 to 1.

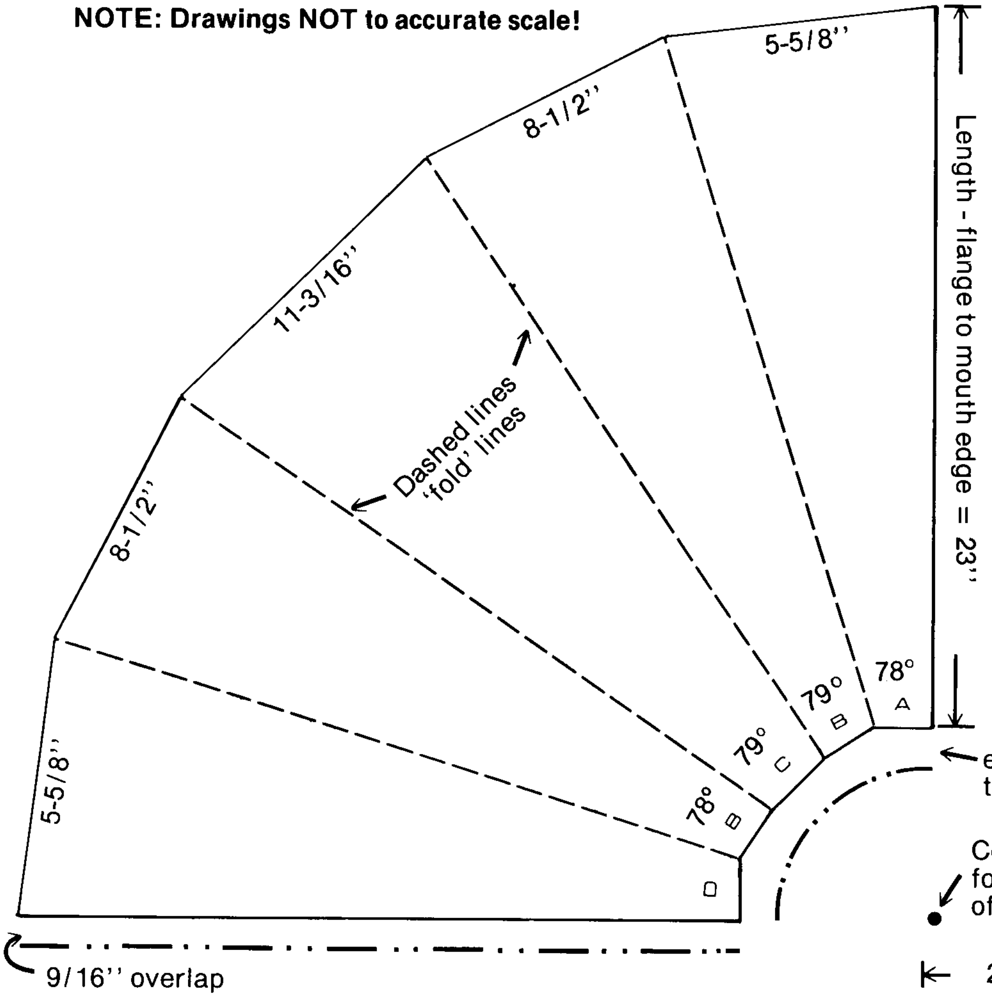
Layout carefully on suitable material (28 gauge Zinc plated steel). Note outer (mouth) dimensions and flange **opening** dimensions. Overlap (lower left) allows lapping of #2 'long side opening' during soldering operation. Extra ½" trim piece at flange end allows precise trimming of small end with metal saw. **A side** trims at 12° while **B side** trims at 10°. Flange plate sketch shown must mate with equivalent flange on LNA. A, B, C, D dimensions (narrow end of horn) to right.

Flange End Dimensions

(material cut size)

A = 1-11/16"
B = 1-3/16"
C = 2-5/16"
D = 1-3/8"

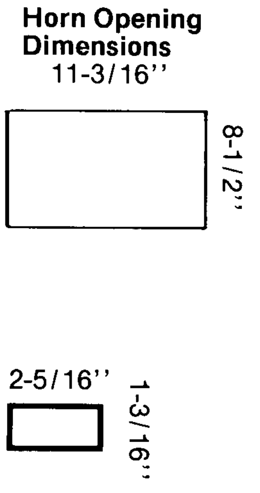
NOTE: Drawings NOT to accurate scale!

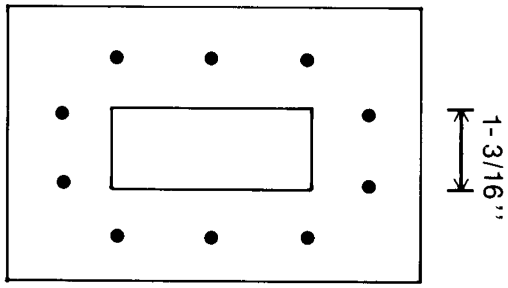


← extra 1/2" trim piece

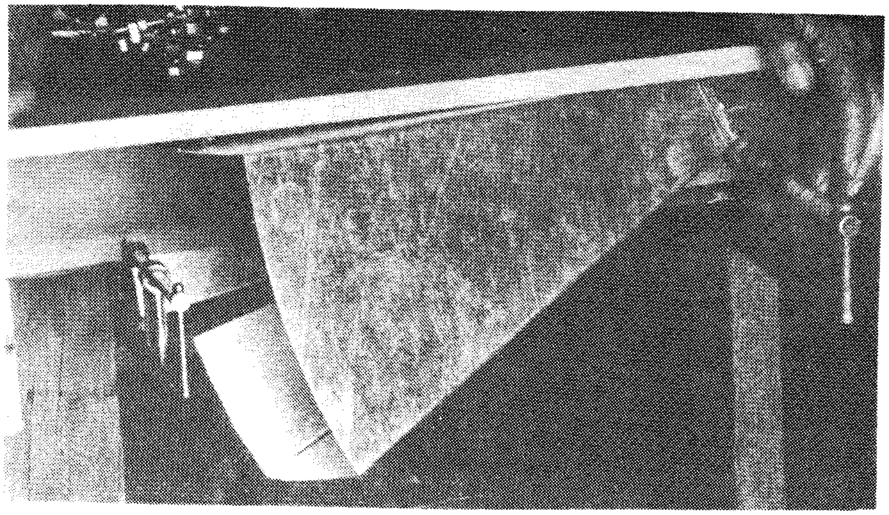
Compass Center Point for scribing portion of circle for horn

Horn Opening Dimensions

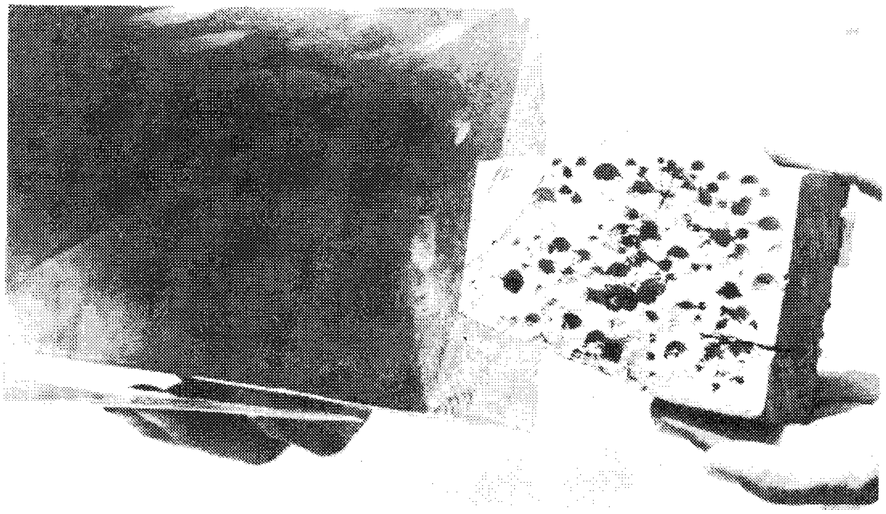




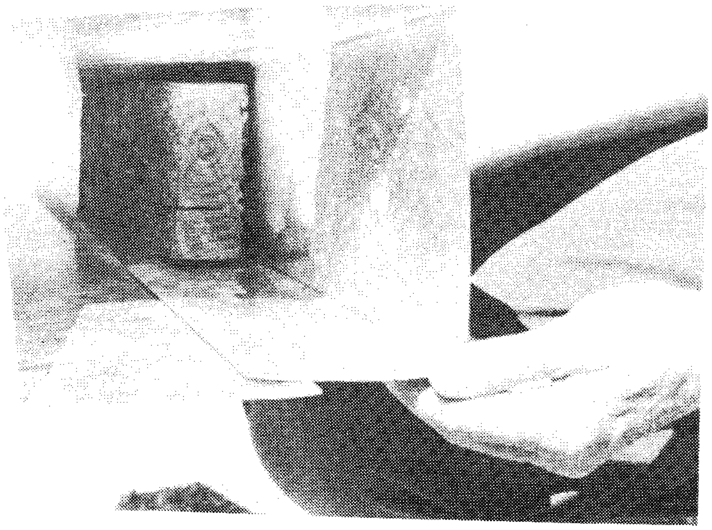
FLANGE ON SMALL END OF HORN MUST MATE WITH FLANGE ON LNA input and mate with tapered end of horn around circumference of 2-5/16" x 1-3/16" cavity opening in plate. Use LNA plate for model.



ZINC PLATED steel material selected for feed horn is carefully (and slowly!) bent into appropriate shape using 2 X 4, 'C' clamps and 1 X 4 to shape antenna along lines previously scribed on flat surface.



BEFORE DOING ANY FINAL adjustment-bending, slide a piece of 2 X 4 or other suitable stock down inside of partially bent-into-shape horn to prevent inside surface area from buckling under bending pressure.



FINAL FORM OF horn can be adjusted with ball peen hammer and gentle bending.

The metal is bent into the proper horn shape along the scribed lines using a bending jig or 'C' clamps and blocks of 2 x 4 or 4 x 4 as a form to bend against.

Take it slow and easy in this process since the efficency of your total system comes into 'focus' with the degree of care you put into the feed horn construction.

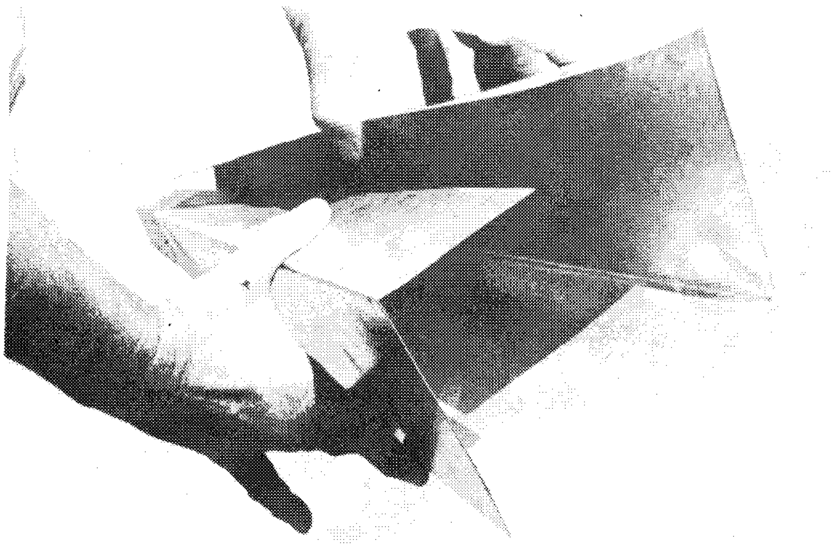
Note: Early attempts to build a feed horn out of PC board were a dismal failure. The PC board has two separate plated surfaces and a dielectric between. This results in all sorts of unpredictable surface currents on the horn and non-linear efficency. Without belaboring the point, PC board makes poor horn material.

The opening at the back of the horn should match exactly the opening at the input to the LNA cavity (where the LNA pick up probe is located; see photo page 22). Under no circumstances should the opening at the flange end of the horn be smaller (in any dimension) than the opening into the LNA cavity as this will cause the low frequency end of the 3.7 to 4.2 GHz band to suffer. There may be a slight advantage to making the flange end opening on the horn slightly larger than the LNA cavity opening (1/64th of an inch on all sides) as this will tend to act as an 'isolator' for matching purposes between the LNA cavity and the horn flange. If you are using a homebrew LNA/cavity without an isolator (virtually all LNAs available have a built in isolator or ferrite coupler on the input), this slightly larger opening may provide isolation and matching for the LNA input stage.

When bending the horn material,

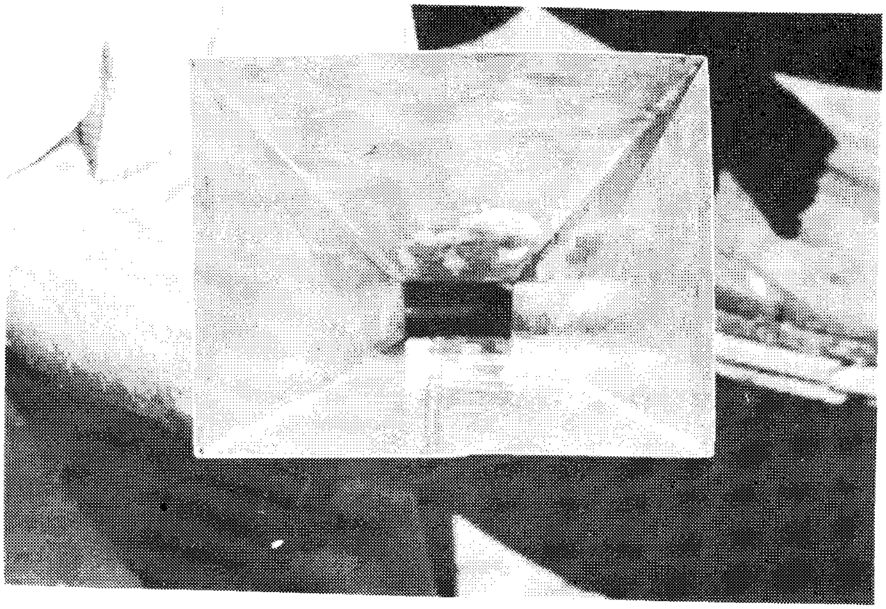
there is a popular theory that suggests you should make all right angles (or bend joints) 'rounded'; that is, slightly gradual rather than 'razor sharp'. Swan subscribes to this approach and he suggests that in order to help the microwave energy maintain the proper mode of transmission, that you in turn bend 'firmly' but with a slight round to the bend rather than a paper-sharp crease.

Note that in the drawing(s) on page 23, the horn's flange fit end is angled to produce a 2-5/16" by 1-1/8" opening to mate with the cavity opening on the LNA. It will be necessary to diagonal cut the outer most 1-1/8" sides at a 12 degree angle and the inner most 1-1/8" sides at a 10 degree angle to end up with a square and snug fit between the small end of the horn and the flange plate that will bolt onto the LNA flange. Again, do this carefully as the efficency of the antenna largely depends upon the care that goes into the horn construction.



FINAL CONTOURED SHAPE is ready for soldering after carefully adjusting overlap to precise dimensions given in text and 'clamping with 'C' clamps and vice grips to hold rigid during soldering operation.

This is a good point to note that the Spherical reflector has phase 'advance' while the special horn design detailed here has phase 'delay'. The advance of the reflector is corrected by the delay of the horn for incoming signals that are out to 20 to 22 degrees off of boresight for the reflector. Between 20 and 22 degrees, suggests Swan, the phase advance and delay of the two intergal parts of the antenna system collapse very suddenly rendering the system useless further off bore-sight than this 20 to 22 degree region. This results in a broad, flat horn pattern with sudden and very steep side skirts and extremely minor side lobes.



FINAL HORN PRODUCT should have 'neat' appearance (indicating care in construction and precision results) with identical measurements on opposing sides.

The horn is positioned so that the widest opening (the 11.2 inch width) is perpendicular to the arriving wavefront. For a vertically polarized signal, the horn when feeding a standard LNA cavity will have its short side (8.5 ") up and down while when receiving horizontal polarization the short side (8.5 ") will be sideways (parallel to the ground).

The soldering job on the inside and the outside of the horn joints must be of high quality. There should be no bumps or bubbles or beads or other dis-continuities greater than 1/64th of an inch. Regular rosin or acid core solder will work on the Zinc plated material but use plenty of heat. Clean the surfaces first with steel wool and make sure you have the horn overlap positioned properly and clamped with 'C' or other clamps so that you have the proper dimensions across the front and rear of the horn before starting. Tack solder several points along the outside and inside, stop and re-check your measurements and then proceed. Don't be afraid to stop and file down a solder buildup (you'll have to do this before you get done anyhow) to maintain the inside surface tolerances necessary. Several pairs of 'vice grips' are recommended to help hold the horn to the proper dimensions while soldering.

Swan makes the following observations about final assembly of the feed horn:

1) Before folding, center punch all lines and scribe all lines with a sharp tool. Drawn-on lines will rub off with handling.

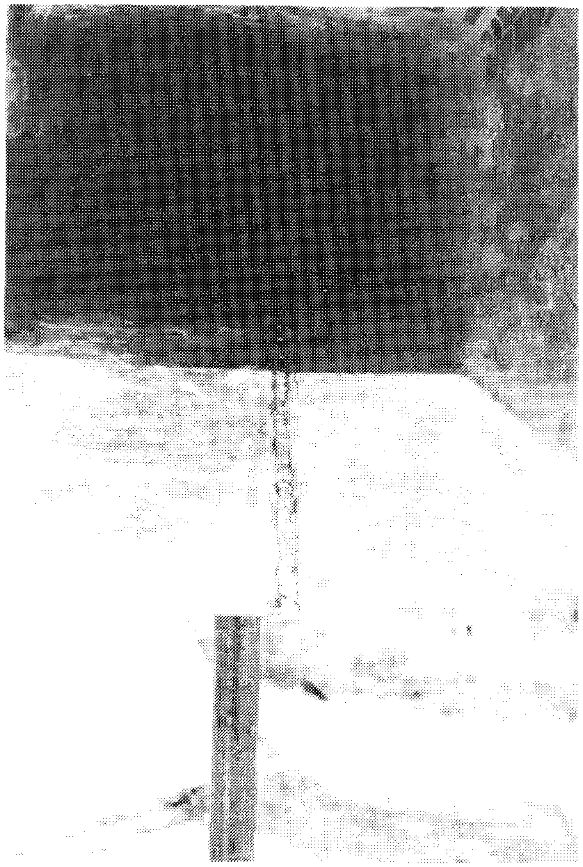
2) Fold using a 4 x 4 block of wood, a vise and 'C' clamps.

3) Measure both sides of an opening, not simply one side.

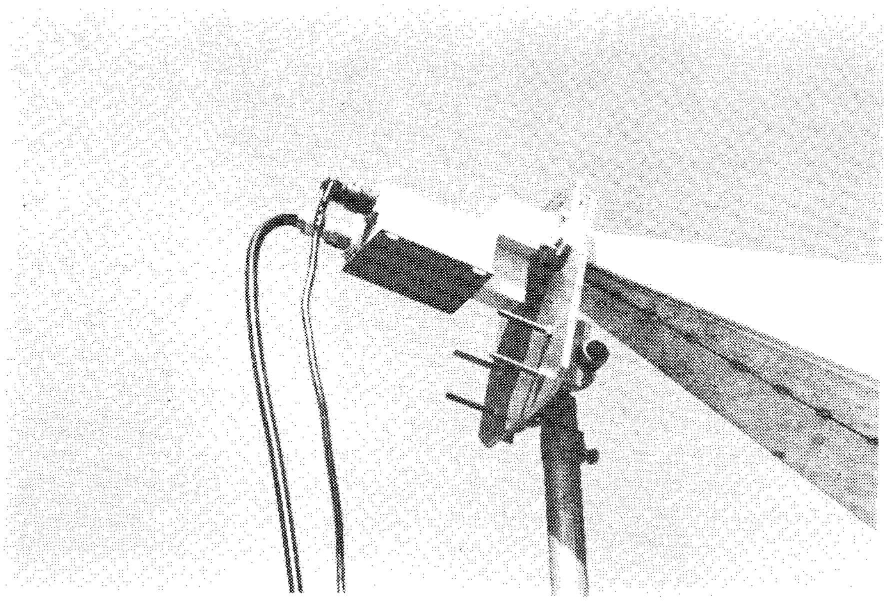
4) Keep the two metal surfaces pressing against each other under tension at all times to insure the solder does not form a 'bulge' under the seam.

5) Carefully think out the cutting/trimming of the small (flange) end of the horn before cutting. You don't want to miss-cut and destroy the horn after all of that work!

6) The flange that solders to the back of the horn (and later mates to the flange on the LNA) is constructed from the same material. It must be soldered very



WELL SOLDERED SEAM will have no protrusions, bumps or dis-continuities more than 1/64th inch off of smooth inner surface. More can be gained (and lost!) in care put into horn construction than any other phase of project.

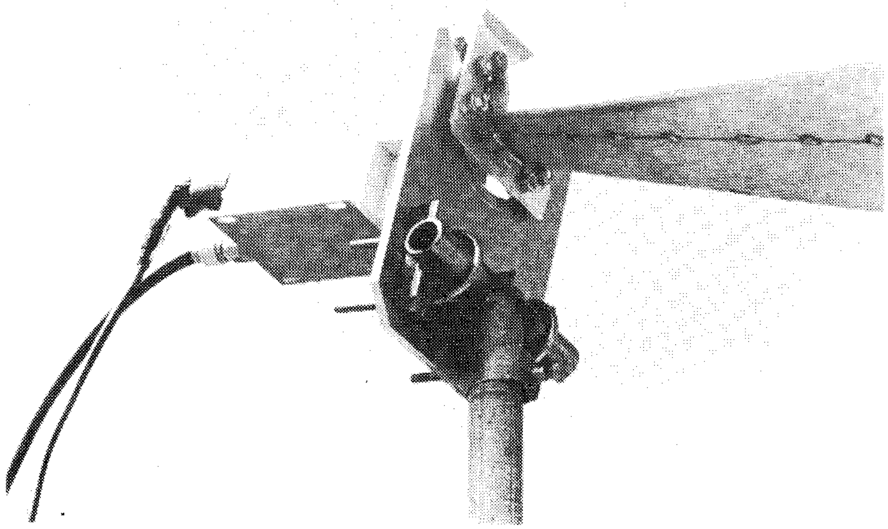


FEED HORN AND LNA IN PLACE on 'slip ring' mount. Note that 'slip ring plate mount' is adjustable in elevation (up and down) plane by slightly loosening two 'U' clamps mounting plate to horizontal pipe.

carefully along all four sides inside and out; filed down smoothly and then checked for snug/flat fit against the LNA flange. Again, use all 10 holes to secure the two flanges together and tighten the bolts well.

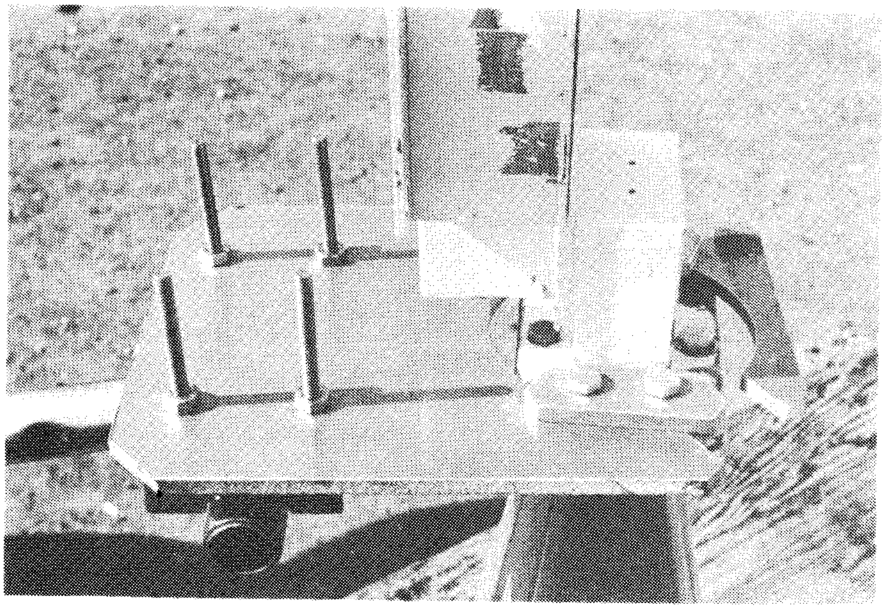
Swan has developed a 'slip ring' system for rotating the LNA + feed horn that will not be detailed here. However if you look closely at the photo at the bottom of this page plus the photo appearing on page 28 you can see that he has cut a circular hole into a piece of aluminum plate and using four of the LNA to horn flange bolts created a set of collars that float either side of the aluminum plate. These four bolts are kept snug but not totally under tension and this allows the user to grasp the horn and rotate the horn + LNA around the circle to change polarizations.

As the photo to the right shows, using a steel pipe 'T' arrangement, the LNA plus horn mounts to the top of the tripod support. By keeping the two 'U' bolts that secure the aluminum plate to the 'T' just snug, you can tilt the feed horn up and down (as in elevation) to make that adjustment with the system.



FRONT VIEW WITH FEED HORN in place on tripod mount.

Note in the photo to the right and on page 28 that a 'slot' is left in the circle on one outer edge to allow sliding the horn + LNA in and out of the mount. The diameter of the circle is 3.5 inches and the width of the 'slot' is 1-3/8".

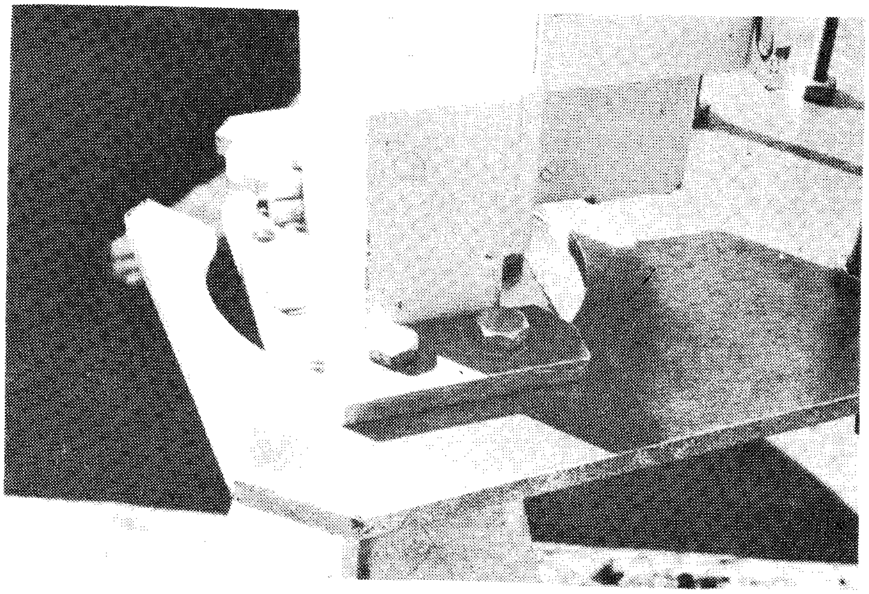


SLIP RING PLATE MOUNT is simply circle cut in ¼ inch aluminum plate with opening to allow LNA plus horn to slide in and out without coming apart. Off-rectangular piece (one on opposite side as well) forms slip-surface.

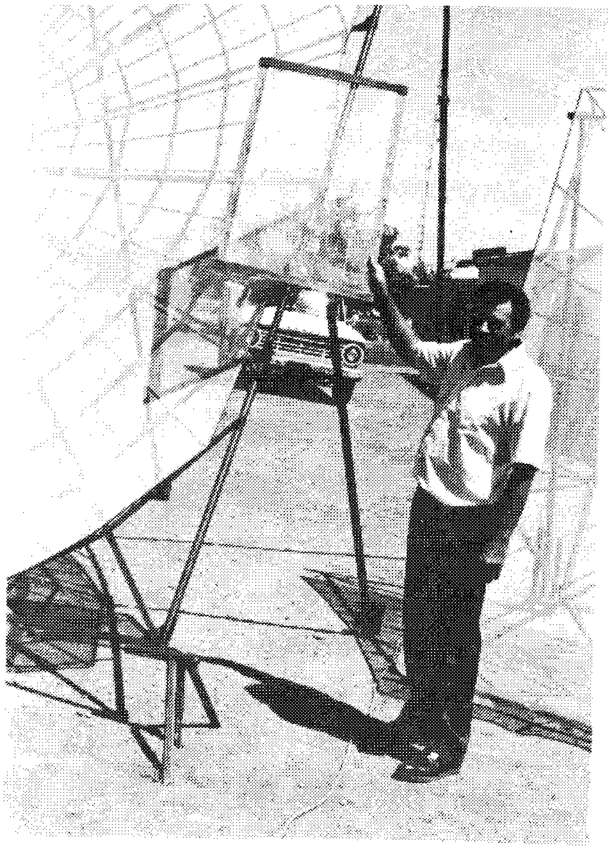
ADJUSTMENT AND NOTES

The following observations and suggestions are offered by Oliver Swan:

1) Make your distance (from Spherical reflector to feed horn antenna) measurements to the center of the horn. Your 1.5 to 1 focal distance is computed



ALTERNATE VIEW of slip ring mounting plate. Bolts that mount LNA flange to horm flange extend through pair of small pressure-tights sliding plates either side of ¼ inch thick aluminum mounting plate.



A SMALL PIECE OF ALUMINUM SCREENING mounted in a frame becomes antenna operations measurement tool. Slowly pass 'false' surface area in front of Spherical surface and note degradation of picture/signal.

from the center of the Spherical surface to the center of the (23" long) feed horn.

2) If you have the feed horn positioned too closely to the Spherical surface, you will find the maximum signal is off of the center of the Spherical surface. Eyeball the alignment from behind the horn; when signal is peaked you should be looking at or almost directly at the center of the Spherical surface.

3) The same effect holds for being too far back although you should notice a big drop in signal level when too far back (more so than when too close in).

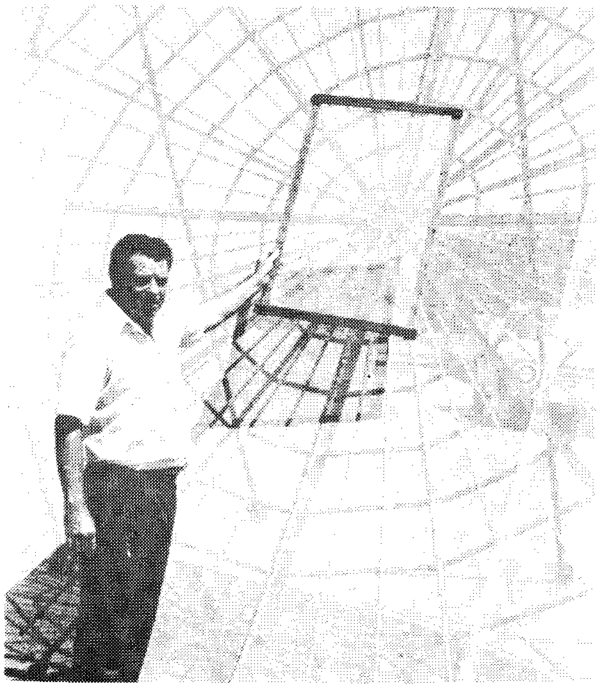
4) If you are too high (above) ground with the feed horn, the signal will peak (visually aligned) below the center. If you are too low with the feed horn, the signal will peak (visually aligned) above the center.

Remember - the antenna feed horn is reciprocal to the Spherical surface. Everything seen at the feed horn is turned around "180 degrees" from the actual event happening at the surface.

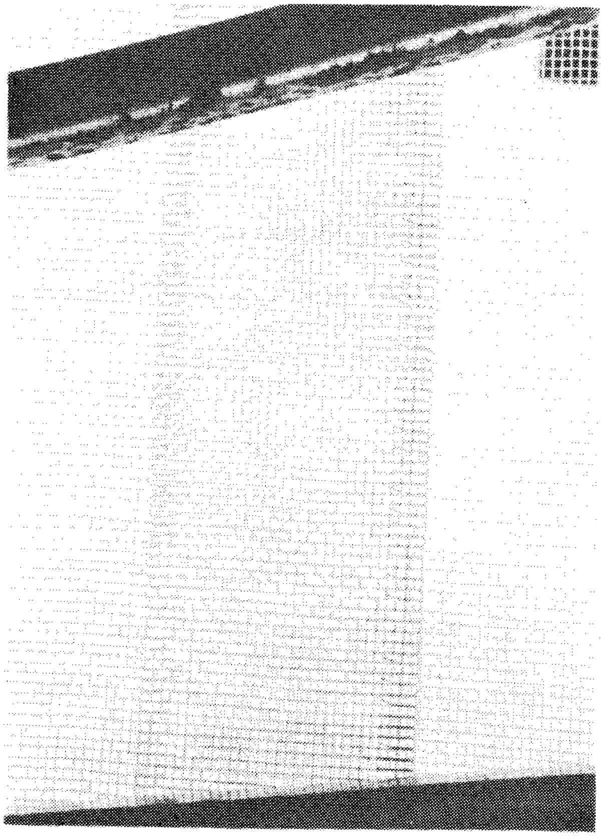
5) The sunlight reflecting on the surface is a good indication of surface accuracy (see photo on pages 8 / 9) . Similarily, you can use a small telescope or transit to eyeball the probe in the LNA while standing behind the reflector and looking into the horn mouth. If you can't see the probe visually, the microwave energy reflecting from that point on the Spherical surface can't get there either!

6) The optimum inclination angle is no more than 20 degrees below the satellite signal's elevation angle for a bore-sight satellite. This is the same (+ or -) 20 degree "field of view" that goes with the Spherical's effective look window.

7) You can check on the performance of the reflector screen by taking a 2 x 2 or 30" by 30" piece of screen in a frame and holding it up before the Spherical surface. Walk along the full width of the surface holding the screen 12 to 24



MOST PRONOUNCED DEGRADATION should take place in center region of Spherical since main lobe of horn feed antenna is concentrated in this region. Low degradation in this region, or abnormally high amounts of degradation off of center suggests antenna is not properly 'sphericalized'.



OVERLAPPING OF SCREEN MESH REFLECTOR is important for mechinical strength which also translates to surface accuracy integrity. Weaving nylon line in and out of full length of overlap is recommended to insure 'flat' surface-to-surface fit.

inches out in front of the reflector surface. Have someone watch a monitor and/or a signal level indicator (through the receiver's demodulator or AGC system). As you start on the edge of the reflector surface moving towards the center the signal level should drop slightly, increasing the amount of signal drop as you move closer to the center of the screen. As you move beyond the center to the opposite side the picture quality and level will regain the original values. By using this method you can 'plot' the reflector surface and the contribution of each portion to the total overall signal received. Because the feed horn is 'down' as much as 17-20 dB at the edges of the antenna, you should expect to see less degradation from the edges (left or right, top or bottom) than you would at the center where the feed horn is bore-sighted.

8) For far northern latitudes, a maximum tilt inclination of 10 degrees is recommended.

9) It is far better to under illuminate the surface of the antenna with the feed horn than to over illuminate it. Earth noise with an over illuminated reflector will degrade the antenna performance sharply.

10) Overlap all screen material (as shown to left) by several inches. A nylon line woven down the overlap area (not done in example) would help insure that there are no 'bumps' in the surface area in the overlap region.

11) In designing your frame structure, the smaller the unsupported areas (i.e. the regions where the surfacing material is pulled taunt between two properly adjusted supports) the better the efficency of the reflector surface. Flat areas 5 inches in the maximum dimension or less are recommended for peak efficency.

12) An advantage to a screen mesh dish perhaps not obvious is that the mesh will not heat up nor will it reflect solar heat towards the LNA and feed antenna. And because of the tilt/inclination angle of the reflector surface, solar energy does not build up around the feed antenna.

And finally this note. An excellent set of video tapes are available showing construction, design and operation of the Swan Spherical antennas for TVRO use (see next page). Commercial versions of these antennas are available directly from:

Mr. Oliver Swan, 200 Swan Road - RR 1
Bisbee, Arizona 85603

SWAN MANUAL SUPPORT MATERIALS

To produce this Swan Spherical TVRO Antenna Manual, STT's Bob Cooper made several visits to Oliver Swan's facility near Bisbee, Arizona. During the course of the development of the Spherical antenna for TVRO work Oliver Swan and Bob Cooper created several hours of color videotape of the antenna's design, construction, adjustment and operation.

Additionally, Swan's appearance at the SPTS '79 (Satellite Private Terminal Seminar) gathering in Oklahoma City in mid-August (1979) placed Oliver before seminar attendees for a total of two hours where he described his work and answered questions. From all of this several Swan videotape sets are now available.

Because all TVRO technology is very fluid, the future developments in this antenna phase of the field will be reported in COOP'S SATELLITE DIGEST; a monthly "technology publication" dealing with the explosive growth of low cost satellite terminals and technology. Order forms for all of these materials appear below.

NOTE: If you do not wish to remove this page from this manual, please be sure to follow the format shown in indicating the materials you are ordering and where these materials are to be shipped.

ORDER FORM - SUPPORT MATERIALS

___ $75 enclosed for VHS (SP) version of 'SWAN SPHERICAL ANTENNA DESIGN', a color videotape of approximately 100 minutes length.

___ $70 enclosed for BETA (L500) version of 'SWAN SPHERICAL ANTENNA DESIGN', a color videotape of approximately 100 minutes length.

___ $125 enclosed for VHS (LP only) version of 'SWAN SPHERICAL DESIGN, OPERATION AND TESTING', a color videotape of approximately 170 minutes length.

___ $120 enclosed for BETA (L750) version of 'SWAN SPHERICAL DESIGN, OPERATION AND TESTING', a color videotape of approximately 170 minutes length.

NOTE: 'Swan Spherical Design, Operation and Testing' includes the basic material found in 'Swan Spherical Antenna Design' plus additional material.

___ $50 enclosed for one year first class mail subscription to CSD / COOP'S SATELLITE DIGEST.

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